

Federal Reserve Bank of Cleveland

Are We in a Productivity Boom? Evidence from Multifactor Productivity Growth

by Paul W. Bauer

With the U.S. unemployment rate at a 30-year historic low and the labor force expected to grow only about 1 percent in the near future, increased productivity could be the key to preserving the country's robust, noninflationary GDP growth. As a result of compounding, even a small boost in annual productivity growth can yield large benefits in the long run. Providing more goods and services without expending additional resources is a sure-fire way of relieving supply-side bottlenecks and improving living standards over time.

Because productivity growth is so important, volumes have been written on how to measure its growth rate and how to nurse an acceleration of that rate. Although the general concept of productivity is straightforward (getting more with less), when we introduce multiple inputs and outputs, scale economies, and quality changes in those inputs and outputs, obtaining estimates becomes considerably more complicated. The presence of any of these factors can bias measures of productivity gains.

Economists have developed a set of precise definitions to explore these jumbled effects. The measure of productivity growth most commonly written about is labor productivity, because it is available quarterly and has a direct bearing on labor income. Under some circumstances, labor productivity is also a good measure of technical change—that is, the boost in output resulting from improvements in technology, even if no more inputs are employed. Technical change is a more precise measure of productivity than labor productivity, because it incorporates changes in the productivity of

other inputs and can adjust for changes in scale economies and the quality of inputs and outputs. Unfortunately, technical change is also harder to measure.

This *Economic Commentary* explores multifactor productivity (MFP), an approach employed by the Bureau of Labor Statistics, and examines the implications of the latest estimates from this approach.¹ MFP overcomes some of the shortcomings of labor productivity as a measure of technical change. By this measure, although private nonfarm business productivity growth rebounded in 1995–97, it has yet to reach the average rate achieved during 1948–73. Based on the relationship between labor productivity and MFP and the apparent short-run stability of its other components, MFP growth will likely be found to have been robust in 1998 as well. In contrast, from 1990 to 1996, manufacturing MFP growth exceeded its 1949–73 rate, with the two most recent years' rates being particularly strong.²

■ The Shortcomings of Labor Productivity

Measuring technical change can seem relatively straightforward when one service (Y) is produced by employing a single input (L). In this case, labor productivity (Y/L) is an obvious measure of the level of productivity, and changes in this level estimate the rate of productivity growth.

Even in this simple case, complications may arise in treating changes in labor productivity as a measure of technical change. First, changes in the quality of the service or in the labor input could bias this measure. For example, if a higher-

Increased productivity could be the key to preserving robust, noninflationary GDP growth. But what is the best measure of productivity? This *Economic Commentary* explores the relationship between labor productivity and multifactor productivity, a measure that accounts for factors other than technological improvement. It concludes that MFP provides a better measure of productivity due solely to technical change.

quality service were offered that required more labor, then labor productivity would appear to fall. This phenomenon is mitigated in practice, because output is usually measured by the value of goods and services produced, particularly when multiple goods and services are involved. Higher-quality output is likely to command a premium price, so the bias due to changes in output quality would be mitigated. Alternatively, improvements in labor quality do not have this offsetting characteristic; rather, higher-quality labor (for example, additional education or training) will likely boost labor productivity, but economists usually want to examine the source of any productivity gains for policy implications. If the gains stem from higher labor quality, then devoting additional resources to training and education may further improve gains. Alternatively, if the source of the gains lies elsewhere, then this policy would not be as attractive.

Another possibility is that the production process exhibits scale economies (or possibly diseconomies). Scale economies are found in industries where unit costs fall as the scale of operations increases. This phenomenon was first studied in pipeline industries at the turn of the century, when it was observed that the amount of material required to make a pipe of a given diameter increased only two-thirds as quickly as the carrying capacity of the pipe. This observation led to larger pipes having lower unit costs. Here, the gain in productivity came not from an advance in technology or higher-quality inputs, but from a larger scale of operations. Again, the source of gains is important because it may affect policy decisions: in industries with scale economies, policy-makers may want to encourage output growth and maybe even consolidation—as long as pricing remains competitive.

Matters get even more involved when there are multiple inputs, a much more realistic case. In this scenario, labor productivity is a biased measure of technical change *if* the employment of other inputs does not increase proportionally to labor. Consider capital deepening—that is, more capital employed per unit of labor. If, for instance, a farmer employs satellite imagery and global positioning technology to more effectively manage his acreage, his labor productivity should rise. However, not all of this gain is technical change, because the farmer is now also employing more capital. The additional capital must be accounted for to obtain a measure of productivity gains resulting *solely* from improvements in technology.

■ Measuring Technical Change

It is useful to disentangle productivity gains that result from technological improvements from gains that result from other sources (capital deepening, changes in input quality, and scale economies). One way to think about technical change is as an outward shift in the production-possibility curve. This curve represents the maximum amount of output that can be produced from a given bundle of inputs. In figure 1, the curve PPF_t represents the combinations of outputs Y_1 and Y_2 that can be produced from inputs available at time t . Similarly, PPF_{t+1} represents the output choices possible at time $t + 1$. Because of advances in technology, more of both outputs can be produced from the fixed bundle of inputs. A measure of technical change should be a single number that

TABLE 1 PRIVATE NONFARM BUSINESS PRODUCTIVITY^a

	1948–97	1948–73	1973–79	1979–90	1990–97	1996	1997	1998
Labor productivity	2.0	2.9	1.1	1.0	1.2	2.5	1.2	2.3
Contribution of capital deepening ^b	0.7	0.8	0.6	0.7	0.4	0.7	0.4	—
Contribution of labor quality ^c	0.2	0.1	0	0.3	0.4	0.4	0.3	—
Multifactor productivity	1.1	1.9	0.4	0	0.4	1.5	0.4	—

a. Excludes government enterprises.

b. Calculated as the growth rate in capital services per hour multiplied by capital's share of current dollar costs.

c. Calculated as the growth rate of labor composition (the growth rate of labor input less the growth rate of hours of all persons) multiplied by labor's share of current dollar costs.

NOTE: Multifactor productivity and contributions may not equal labor productivity due to independent rounding.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 2 PRODUCTIVITY IN MANUFACTURING

	1949–96	1949–73	1973–79	1979–90	1990–96	1995	1996
Labor productivity	2.8	3.0	2.1	2.6	3.4	3.9	4.1
Multifactor productivity	1.3	1.8	-0.6	1.0	1.7	3.8	2.1

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 3 MANUFACTURING INDUSTRIES: MULTIFACTOR PRODUCTIVITY TRENDS, 1949–96

Industry	Average annual growth rates (percent)				
	1949–96	1949–73	1973–79	1973–96	1990–96
All manufacturing	1.2	1.5	-0.5	1.0	1.7
Nondurable manufacturing	0.7	1.4	-0.5	0.3	0.3
Durable manufacturing	1.5	1.5	-0.5	1.6	3.0
Industrial and commercial machinery	1.6	0.7	-0.2	2.9	4.6
Electrical and electronic machinery	2.9	2.0	1.1	2.6	8.9

NOTE: Multifactor productivity measures by industry are not directly comparable to measures for aggregate manufacturing because industry measures exclude transactions only within the specific industry, while the aggregate manufacturing measures also exclude transactions between all manufacturing industries.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

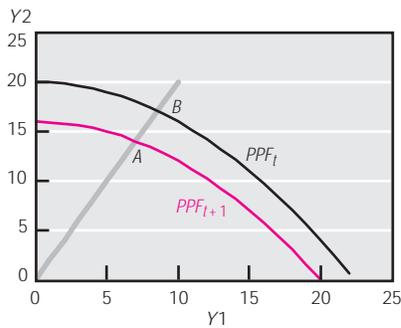
describes the shift in the production-possibility curve from PPF_t to PPF_{t+1} , say, from A to B .

The most widely reported measure of technical change is calculated by the BLS and is reported as the *multifactor productivity index*, also referred to in other contexts as *total factor productivity* or the Solow residual. MFP is less widely known and reported than labor productivity because it is only available annually and is only released biennially. The reason for the delay and the relative infrequency of reporting is that MFP requires more data to calculate. Labor productiv-

ity requires only estimates of output and labor input, both of which are available quarterly. In addition to output and labor, MFP also requires an estimate of capital, which is only available annually.³

For the purposes of this study, we have abstracted from productivity changes due to scale economies. While the assumption of constant returns to scale could be a problem for some industries, it is a reasonable approximation for the economy as a whole and for most subsectors. For sectors in which this assumption is not reasonable, the estimated technical change will be biased upward when out-

FIGURE 1 TECHNICAL CHANGE



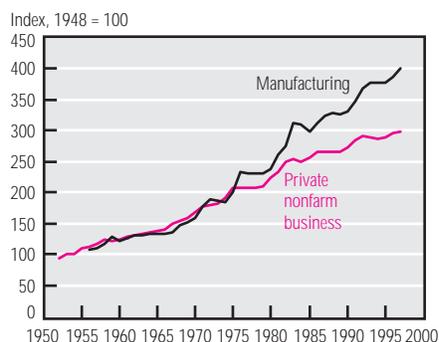
SOURCE: Author's calculations.

FIGURE 2 PRIVATE NON-FARM BUSINESS PRODUCTIVITY MEASURES



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

FIGURE 3 CAPITAL DEEPENING



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

put is growing, as some of the gains attributed to technical change will actually accrue from exploiting scale economies. In analyzing the latest MFP growth estimates, we will make use of a decomposition that separates labor productivity gains into effects stemming from MFP growth, capital deepening, and improvements in labor quality.⁴

MFP Growth Estimates

Because MFP growth is not as widely reported as labor productivity, first consider the long-run trends to see how the two measures have related over time. For the private nonfarm business sector, both labor productivity and MFP have grown sharply since 1948 (see figure 2 and table 1). The postwar pattern for labor productivity is well known. In the “golden age,” 1948–73, growth averaged 2.9 percent annually. From 1973 to 1990, though, labor productivity was only 1.1 percent. The overall rate in the 1990s has shown a barely perceptible increase to 1.2 percent. This rate appears to have increased in the last year of available data; however, the 2.3 percent rate reported for 1998 stills falls short of the 2.9 percent rate averaged in the golden age.

Table 1 shows how the sources of labor productivity gains have changed over time. Technical change, as measured by MFP growth, accounted for well over half of labor productivity gains in the golden age, averaging 1.9 percent annual growth. Now, however, it accounts for only one-third. From 1973 to 1979, MFP growth fell to 0.4 percent and then plummeted to zero from 1979 to 1990. During the 1990s, MFP growth has recovered to 0.4 percent, yet it is still below the rate posted during the golden age.

The share of labor productivity growth attributed to capital deepening has been about one-third over the postwar period. The magnitude of the contribution has fallen as the growth rate of capital slowed (see figure 3). In the golden age, it accounted for 0.7 percentage points of the observed growth in labor productivity, but now accounts for only 0.4 percentage points.

In the 1990s, improvements in labor quality in the form of additional education and work experience accounted for one-third of labor productivity gains. This is a significant change since the golden age, when improvements in labor quality boosted labor productivity only 0.1 percentage points. In the 1990s, improvements in labor composition have

contributed 0.4 percentage points to labor productivity growth.

Because of the relationship between labor productivity and MFP, we can use more recent estimates of labor productivity to forecast MFP. Given that labor’s cost-share is 65 percent–70 percent (depending on the economic sector under consideration); that the capital deepening and labor quality components of the decomposition tend to remain stable in the short run; and that labor productivity has been strong the last couple of years, MFP growth should have been robust in the years for which data on MFP are not yet available. Of course, it should be remembered that the U.S. economy has been in the midst of a capital investment boom, with capital services accelerating to a growth rate of 4.4 percent, the highest rate since 1984. Thus, it is conceivable that capital deepening could be driving a slightly larger share of labor productivity, cutting into that which might be provided by MFP.

The patterns for manufacturing’s labor productivity growth and MFP growth are similar, but with an important twist (see table 2). Unlike private nonfarm business, manufacturing’s MFP and labor productivity in the 1990s have actually surpassed that experienced 1949–73. The BLS also estimates MFP for specific manufacturing industries (see table 3).⁵ Durable manufacturing’s recent 3.0 percent annual growth rate is double that experienced in the golden age; however, the corresponding figures for nondurable manufacturing are only 0.3 percent and 1.4 percent, respectively. While most nondurable manufacturing industries have underperformed the MFP growth rates achieved in the 1949–73 period, durable manufacturing has a few sectors for which the 1990s are the golden age. In particular, industrial and commercial machinery and electrical and electronic machinery have had MFP growth during the 1990s far exceeding that achieved from 1949 to 1973. As these two sectors encompass computers and telecommunications, rapid technical change is not too surprising; however, these are also two sectors where the assumption of constant returns to scale may be the most tenuous, so some of these gains may be the result of exploiting scale economies.⁶

■ Summary

This *Economic Commentary* has explored the relationship between labor productivity and technical change (multifactor productivity). While labor productivity is a useful measure, it can be affected by factors other than improvements in technology, such as scale economies, multiple inputs, and quality changes. The MFP growth indexes are a better measure of productivity gains due solely to changes in technology.

Private nonfarm business productivity growth has rebounded in recent years, but it has yet to reach the average rate achieved in 1948–73. However, manufacturing's MFP growth has exceeded its golden-age rate in the 1990s. Most of this gain is concentrated in durable manufacturing, mainly commercial and industrial machinery and electrical and electronic machinery. Because of labor productivity's large share in the MFP index and the short-run stability of the effects of capital deepening and changes in labor quality, MFP growth will likely be found to have been strong in 1998 once those data become available.

■ Footnotes

1. For complete details on how the Bureau of Labor Statistics calculates its MFP indexes, see the *BLS Handbook of Methods*, Chapter 10, "Productivity Measures: Business Sector and Major Subsectors," April 1997.
2. The years for which statistics are reported for private nonfarm business and manufacturing differ because of data availability.
3. For the more detailed manufacturing MFP indexes, estimates of employment in energy, materials, and business services are also required, resulting in further delays.
4. For details, consult the *BLS Handbook of Methods*.
5. In addition to labor and capital, energy, nonenergy materials, and purchased business services inputs are included. Due to the availability of data for these additional inputs, MFP estimates extend only to 1996.
6. For more on the relationship between computers and productivity, see Robert J. Gordon, "Has the 'New Economy' Rendered the Productivity Slowdown Obsolete?" Northwestern University, working paper, June 1999.

Paul W. Bauer is an economic advisor at the Federal Reserve Bank of Cleveland.

The views stated herein are those of the author and not necessarily those of the Federal Reserve Bank of Cleveland or of the Board of Governors of the Federal Reserve System.

Economic Commentary is published by the Research Department of the Federal Reserve Bank of Cleveland.

To receive copies or to be placed on the mailing list, e-mail your request to 4d.subscriptions@clev.frb.org or fax it to 216-579-3050. Economic Commentary is also available at the Cleveland Fed's site on the World Wide Web: www.clev.frb.org.

We invite comments, questions, and suggestions. E-mail us at editor@clev.frb.org.

Now on our Web site! See a glossary of terms used in the Economic Commentary when you visit us online.

**Federal Reserve Bank of Cleveland
Research Department
P.O. Box 6387
Cleveland, OH 44101**

Address Correction Requested:

Please send corrected mailing label to the above address.

Material may be reprinted if the source is credited. Please send copies of reprinted materials to the editor.

**BULK RATE
U.S. Postage Paid
Cleveland, OH
Permit No. 385**