Productivity Growth and The American Business Cycle

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Why do free-market economies experience booms and recessions? Until recently, economists attributed business cycles either to well-meaning but misguided economic policy or to inexplicable waves of optimism and pessimism about future business conditions. For instance, Nobel laureate Milton Friedman advocates a nonactivist monetary policy on the grounds that erratic growth in a country's money supply is the most significant factor in economic instability. A different view, shaped by the ideas of the late John Maynard Keynes, holds that business cycles are caused by unpredictable changes in the willingness of investors to lend money to businesses, changes that mirror shifts in investor optimism concerning the future.

In contrast, some recent research suggests that business cycles in the United States are mostly the consequence of unpredictable fluctuations in productivity. This view, which was put forth by Finn Kydland and Edward Prescott in the early 1980s, takes as its starting point the sources of long-term economic growth in the United States. Numerous studies have shown that the mainspring of economic growth in the United States is growth in the productivity of inputs used to make goods and services or, broadly speaking, technical progress. Kydland and Prescott observe that these studies also show that growth in the productivity of inputs does not occur at a steady rate, and they argue

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further that unpredictable fluctuations in the rate of productivity growth is one of the main causes of the short-run economic fluctuations that we call business cycles.

Most strikingly, Kydland and Prescott deemphasize the role that flaws in the institutions or structure of market economies play in business cycles. Unlike Friedman, who has argued that business cycles are mainly the result of unpredictable fluctuations in the supply of money, and Keynes, who thought that instability arose from an economy's exposure to inexplicable changes in people's expectations about future economic conditions, Kydland and Prescott claim business cycles are the result of an economy's adaptation to changes in the productivity of its inputs. These changes arise, for the most part, from deep-seated and unpredictable forces governing technical progress over the entire spectrum of industries. Clearly, if this view comes to dominate people's perceptions about business cycles in the United States and other countries, it would engender a different approach to the scientific and policy problems associated with business cycles. For this reason it merits close attention.

CAN ERRATIC PRODUCTIVITY GROWTH CAUSE BUSINESS CYCLES?

To answer this question we need to know more about what happens during business cycles and how productivity growth is measured and what it means. Let's begin with what happens during business cycles.

Business Cycles. Business-cycle expansions and contractions influence, to varying degrees, all sectors of the economy. Indeed, this *co-movement* of all kinds of business activity is one central feature of business cycles. We have plotted the co-movement between expenditure on all types of consumption goods and all types of investment goods from the third quarter of 1955 to the second quarter of 1988 (Figure 1). As is quite evident, in quarters in which consumption expenditure was above trend, investment expenditure was generally above trend as well. This co-movement is also evident in deviations from trend of total output (real GDP) and total hours worked in the U.S. economy (Figure 2).

Another central feature of business cycles is that quarters of above- and below-trend business activity do not follow each other in rapid succession. For instance, quarters in which output was above trend tend to be bunched together as are quarters of below-trend output (Figure 2). Consumption and investment expenditure display the same pattern. In other words, while all expansions eventually end in contractions and vice versa, business activity demonstrates a clear element of *persistence.*

Therefore, to be an important cause of business cycles, erratic productivity growth must lead to these documented co-movements and patterns of persistence. This brings us to the next questions, namely, what does productivity growth mean and how is it measured.

What It Means. Total output of an economy is the sum of value-added in all firms. The *value-added* in a firm during a quarter is the value of goods and services produced by the firm in that quarter less the value of goods and services purchased from other firms and used up in production in that quarter.[1] Clearly, total output is related to the total time people spend working in these firms and the quantity of producers' goods (such as machinery or buildings) that assist in production. We will refer to

[1]Goods and services purchased from firms and used up in production in the same quarter are called intermediate inputs. When value-added is summed over all firms, purchases of intermediate inputs cancel out, and all that remains are goods and services sold to consumers and goods and services sold to firms but not used up in production during that quarter. Hence, total output could also be calculated as the value of final goods and services (i.e., goods and services that are *not* intermediate inputs) sold by firms during a quarter.

FIGURE 1

Co-Movement of Consumption and Investment*

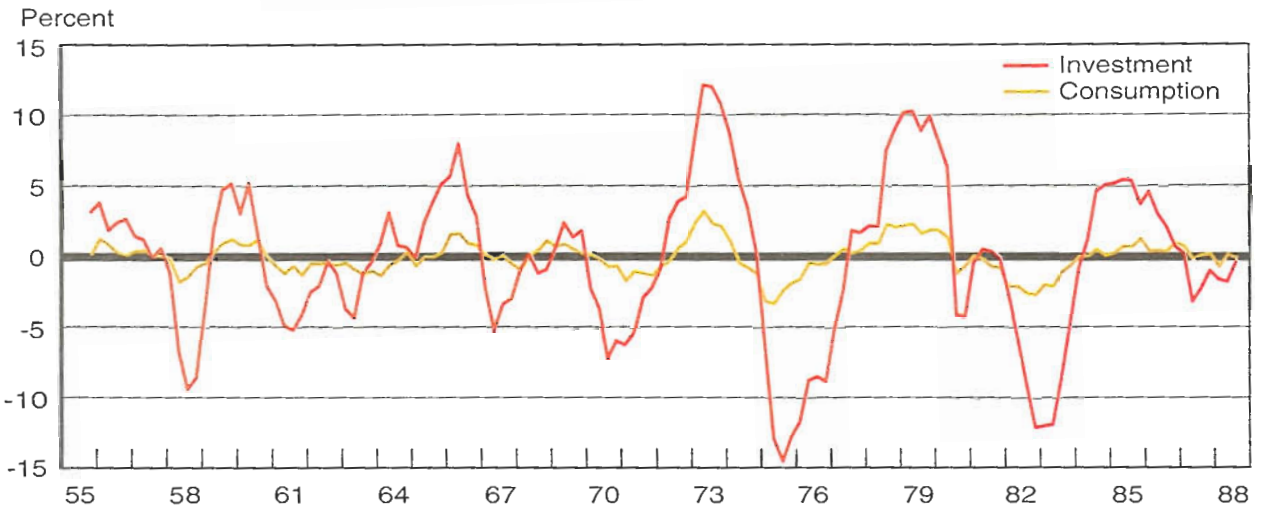


*Figure shows percentage deviations from trend. The trend was calculated using the procedure described by Robert Hodrick and Edward Prescott. The percentage deviation from trend is simply 100 times the ratio of the difference between the actual and trend value of a variable to its trend value.

FIGURE 2

Co-Movement of Output and Hours Worked*

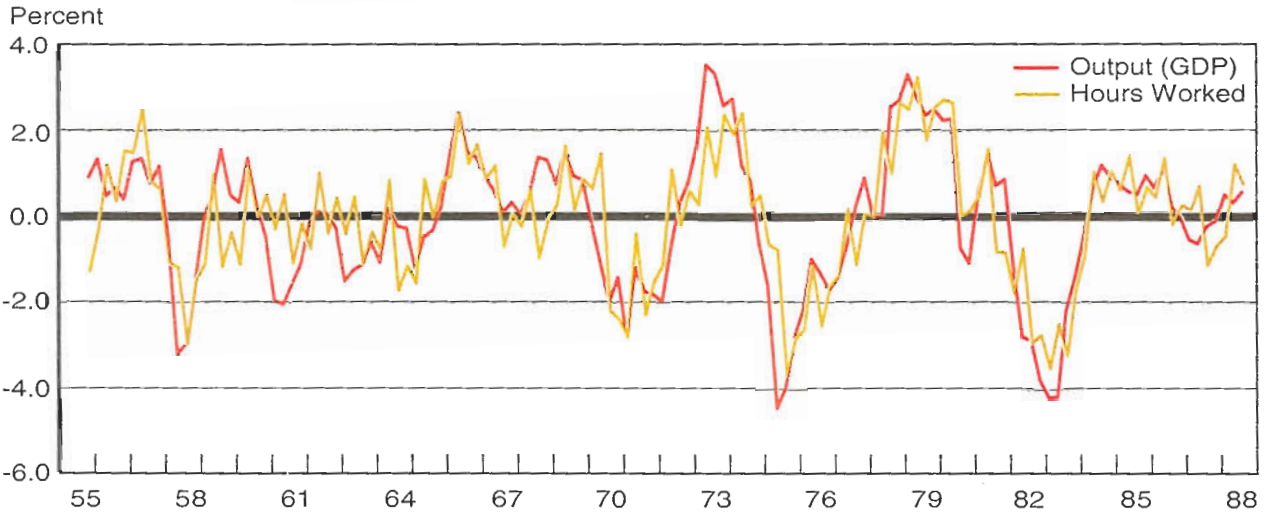


*Figure shows percentage deviations from trend. The deviation from long-term trend for hours worked is an average of the actual deviation for a quarter and the actual deviations for the preceding and following quarters.

the total time put into the production of goods and services in a quarter as *labor-hours* and the producers' goods that assist in production as *capital*. If more labor-hours or more capital is employed in production, total output is higher.

Total output could also change if the *effectiveness* of labor-hours or capital changes. For instance, suppose a manufacturer of plastic toys figures out some mechanical modification that reduces wastage of plastic, i.e., allows the firm to make the same quantity of toys with less plastic. Then, value-added at any given levels of labor-hours and capital will be higher. Economists refer to such changes in value-added as growth in *total factor productivity* (TFP). Kydland and Prescott use this concept of productivity in their work.

As noted above, growth in TFP occurs when firms invent more efficient ways of making existing products. TFP growth could also occur for other reasons. For example, if a firm invents a new product and sells it profitably, TFP is higher because production of the new good draws workers and capital away from the production of less profitable products. Since total output is the sum of value-added in the production of all goods and services, the replacement of less profitable products with more profitable ones raises total output. With no change in the overall amount of labor-hours or capital, the increase in total output amounts to an increase in TFP.

Certain events can cause TFP to decline. For instance, stiffer environmental protection laws that force firms to use less damaging production methods will typically lead to lower value-added for a given quantity of inputs. This occurs because firms will have to divert some portion of available labor-hours and capital to maintaining environmental quality, and these inputs will not be available for production. TFP could also decline if the price of some imported input increases (a good example for most countries is oil).

How It's Measured. Changes in TFP reflect changes in the technological and regulatory environment facing firms and changes in the price of imported inputs. Macroeconomists are interested in a measure of TFP that applies to the economy as a whole. Thus, the idea is to calculate, for each quarter, the growth in total output that can be attributed to growth in total labor-hours and total capital in that quarter and think of the remaining growth in output as an estimate of the growth in economywide TFP for that quarter.

Economists who have researched the sources of economic growth have suggested the following formula for calculating the percentage change in TFP in a given quarter:[2]

% change in TFP in a given quarter =
(% change in total output in that quarter)
-0.64(% change in labor input in that quarter)
-0.36(% change in capital input in that quarter).

We have plotted the percentage change in TFP from the third quarter of 1955 to the second quarter of 1988 (Figure 3). The average annual growth of TFP has been around 0.7 percent, but actual growth has fluctuated quite a bit around this average value.[3]

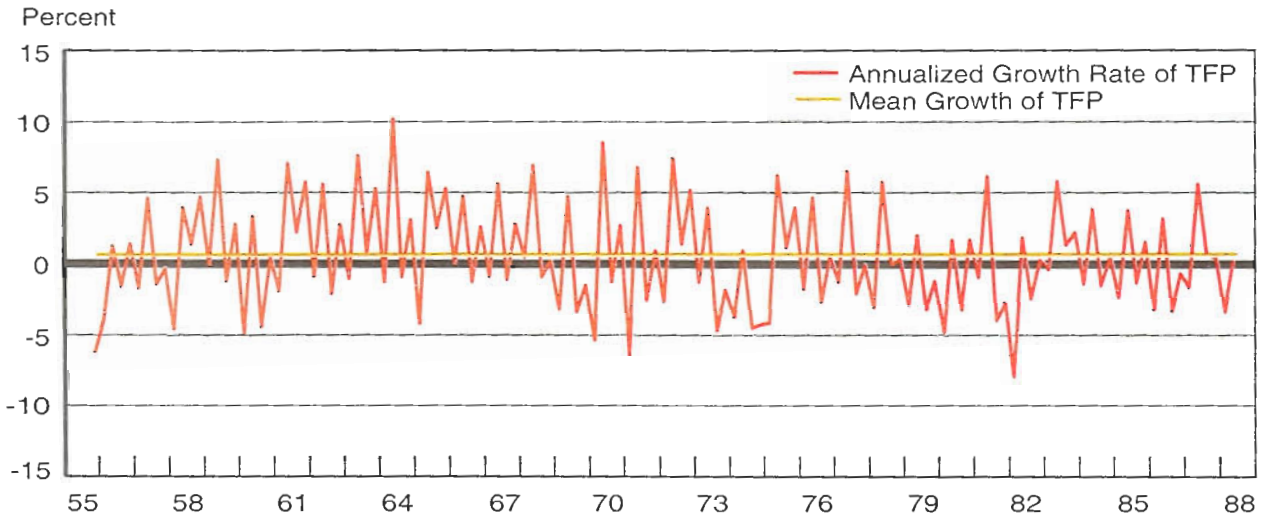
Productivity Fluctuations and the Business Cycle. Kydland and Prescott point out

[2]This formula applies only to the United States and is based on the estimate that 64 percent of total output in the United States is due to the time that workers put into the production process and the remaining output is due to producers' goods that assist in production (see Edward Prescott's 1986 article). In such a situation, economic theory suggests that a 1 percent increase in labor-hours should lead to a 0.64 percent increase in total output, and similarly, a 1 percent increase in capital stock should raise total output by 0.36 percent. For a more detailed discussion of these ideas, consult Robert Solow's classic article published in 1957.

[3]The standard deviation of quarterly TFP growth (defined as the square root of the average of the squared deviations of TFP growth from its mean) is 3.6 percent.

FIGURE 3

Annualized Growth Rate of TFP*



* The percentage changes plotted are the average of the actual percentage change in a quarter and the actual percentage changes for the preceding and following quarters.

that fluctuations in TFP growth could account for the co-movement and persistence of economic variables that characterize business cycles. A quarter in which TFP's rate of growth is above average is a time in which growth in the opportunities for gainful employment of labor and capital is also above average. To exploit this growth, firms invest more than usual in buildings and equipment. This above-average demand for capital goods, in turn, leads to an above-average increase in the demand for workers. The additional income generated directly by above-average TFP growth and indirectly through the increased production of capital goods will lead to an increase in consumption. Thus, total output, consumption, investment, and hours worked will rise above their respective long-term trends simultaneously. Also, it is natural to think that the adaptation to an unexpectedly higher level of productivity cannot be accomplished in a single quarter and that the macroeconomic variables will tend to be above their long-term trends for some length of time.

But do fluctuations in TFP growth generate enough volatility in total output to be an important factor in business cycles? To investigate this point, Kydland and Prescott used a numerical model incorporating information on various aspects of U.S. technology and consumer tastes to calculate how much total output might vary in response to erratic TFP growth of the kind shown in Figure 3. To their surprise, they found that erratic TFP growth made total output in their model about half as variable as actual total output in the United States. Following a decade of additional research, they estimate that TFP fluctuations makes total output 70 percent as variable as actual U.S. output.[4] So, the answer to the ques-

[4]This estimate is presented in Kydland and Prescott's article published in 1991.

tion "Can erratic productivity growth cause business cycles?" turns out to be a resounding yes.

BUT IS IT REALLY?

As one would expect, not everybody agrees with Kydland and Prescott. The controversy that followed publication of their work has centered on whether the U.S. economy has really experienced fluctuations in TFP growth of the magnitude shown in Figure 3 and, therefore, whether Kydland and Prescott's 70 percent figure is a gross overestimate.

There are good reasons to be skeptical of the assertion that measured movements in TFP represent true fluctuations in TFP. These reasons include the fact that measuring inputs and outputs involves errors, and these errors have the effect of exaggerating fluctuations in TFP growth. Some macroeconomists believe that these errors in measurement are so grave that nothing useful is learned about U.S. business cycles from the body of work that Kydland and Prescott have initiated. To determine whether such an assessment is justified, we must dig a bit deeper into these problems.[5]

Measurement Problems. Recall that the basis for calculating TFP growth is the observation that the percentage change in TFP must equal the percentage change in output minus 0.64 times the percentage change in labor-hours and 0.36 times the percentage change in capital stock. Critics have noted two ways in which this equation can overstate fluctuations in TFP. The first has to do with inaccuracies in the measurement of output, labor-hours, and capital stock, and the second with the fact that data on labor-hours and capital stock do not record how intensely these inputs were used.

Mismeasurement of TFP growth due to inaccurate data. Suppose that the percent changes in output and capital stock in a given quarter are correctly measured as 1 and 0 percent, but that the percent change in labor-hours is measured as 3/4 percent when the true change is 1 percent. Then, the measured growth in TFP will be 0.48 percent when the true growth is 0.36 percent. In the following quarter, labor-hours might be overmeasured by 1/4 percent, in which case measured TFP growth will be lower than actual TFP growth. Thus, errors in measuring hours worked make measured TFP growth appear more volatile than it actually is. In the same way, inaccuracies in the measurement of capital stock and output also make measured TFP growth more volatile than actual TFP growth.

Errors in the measurement of hours worked are the most damaging. Errors in the measurement of capital stock probably distort measured TFP growth by minuscule amounts because the quarterly percentage variation in capital stock is small. In contrast, quarterly movements in hours worked are large and receive nearly twice the weight in the TFP equation compared to quarterly movements in the capital stock.

Fortunately, Kydland and Prescott could at least partially correct for measurement errors in hours worked by combining information on employment changes from the two independent monthly surveys of employment, namely, the household survey and the establishment survey. This correction led to a fall in the average variability (standard deviation) of TFP growth by four-fifths. Kydland and Prescott (and others) have used this lower figure in their work.[6]

[5]Critics have noted other objections as well, but these have turned out to be less important. See the 1986 article by Lawrence Summers for a more comprehensive list of criticisms and Prescott's 1991 lecture for a (partisan!) update on the ongoing debate.

[6]Kydland and Prescott do not address the problems created by measurement errors in total output, although such errors undoubtedly exist. Consult Robert Waldmann's 1991 article for an example of how measurement errors in value-added can lead to misleading conclusions.

Mismeasurement of TFP growth due to varying input utilization. This type of error stems from the fact that the government collects information on inputs purchased, but what we need to know is how intensively inputs are *used.*

This problem is most severe for capital. Measurements of capital stock are indexes of the quantity of all capital goods put in place by somebody and still in existence. These estimates do not tell us how intensively the capital stock was used over a given quarter. However, we know for a fact that the capital utilization rate does vary. For instance, in a cyclical upswing, closed factories are reopened, and open factories operate longer by increasing the number of shifts.

To see the measurement problem this poses, imagine that as a result of expansionary monetary policy, businesses reopen closed plants and increase the number of shifts in existing plants. Suppose that hours worked and capital utilization both increase 1 percent. It is reasonable to think that a 1 percent increase in capital utilization will have the same effect on total output as a 1 percent increase in the capital stock. Let us assume then that output increases 1 percent as well (0.64 times 1 percent plus 0.36 times 1 percent). However, the increase in the capital utilization rate is not recorded in the data on capital stock. Since an increase of 1 percent in hours worked is assumed to lead to an increase of 0.64 percent in total output, the TFP calculation will attribute the missing 0.36 percent increase in total output to a 0.36 percent increase in TFP: the calculation will make it seem that TFP grew when, in fact, it didn't. Thus, cyclical movements in capacity utilization rates will cause measurements of TFP growth to be more variable than actual TFP growth.[7]

In response to this criticism, Kydland and Prescott have noted that, contrary to what one might think, variations in the capital utilization rate might raise the estimated importance of TFP fluctuations in business cycles. In an article published in 1988, they presented a modified version of their numerical model in which, whenever hours worked changed, half of the change was accompanied by a corresponding change in capital utilization. They found that while this correction *lowered* the estimated variability in TFP growth, the fact that firms varied their rate of capital utilization made for a more vigorous response of economic activity to above-average productivity growth. Thus, the overall effect was to raise the variability of total output rather than to lower it.

A cyclically varying utilization rate plagues the measurement of labor-hours as well. The government collects information on the number of hours for which workers are paid but not on the number of hours they actually work, i.e., no information is collected on the fraction of time workers are idle on the job. It is probable that a portion of the cyclical increase in total output results from a reduction in the idle time of workers: workers are busier in booms than in recessions. Of course, the TFP calculation would erroneously attribute any change in output that results from a change in idle time to a change in TFP, so that measured TFP would appear more variable than actual TFP.

However, the issue of worker utilization is more subtle than that of capital utilization in one respect: firms don't buy workers the way they buy plant and equipment, and they don't have to hold on to temporarily idle workers the way they have to hold on to temporarily idle plant and equipment. Why keep surplus workers if it's possible to fire them now and rehire them (or their substitutes) when business con-

[7]The problem also occurs if the economy is responding to above-average growth in TFP because capacity utilization increases during such times as well. Since this increase goes unmeasured in the capital stock data, the TFP calculation will make TFP growth appear stronger than it really is.

ditions improve? Proponents of the so-called "labor hoarding" view suggest that there are costs to hiring and firing workers, and rather than bear these costs, firms might be inclined to vary how hard they use their workers. Thus, if business is temporarily slow, firms might have some employees report to work even though there isn't enough work to occupy them for the entire day.

Thus, the extent to which a variable worker utilization rate matters for Kydland and Prescott's conclusions depends on the magnitude of hiring and firing costs. Unfortunately, reliable information on hiring and firing costs is currently lacking. However, in an article published in 1993, Craig Burnside, Martin Eichenbaum, and Sergio Rebelo have shown that if these costs are large, output variability induced by TFP fluctuations could decline from 70 percent to somewhere between 35 and 50 percent of actual variability in U.S. output. Thus, labor hoarding might turn out to be an important qualification to Kydland and Prescott's findings.

WHAT DOES IT MEAN FOR MONETARY POLICY?

All things considered, Kydland and Prescott have presented a surprisingly strong case for fluctuations in TFP growth as a cause of business cycles in the United States. Even a conservative estimate attributes about one-third of variability in U.S. output to TFP fluctuations and the correct estimate may well be higher. Thus, it is worthwhile to ask what implications their findings have for the conduct of monetary policy.

One of the central problems in choosing monetary policy is that the Fed is concerned both with cushioning the economy in recessions and protecting it from inflation. Unfortunately, the twin goals of maintaining full employment and low inflation at times conflict. In the past, the Fed sometimes tolerated higher inflation in the hope (usually belied by events) of avoiding rising unemployment.

However, if Kydland and Prescott are correct and business cycles are mainly a response to fluctuations in TFP growth, the need for stabilizing employment is less clear. An economy faced with above-average productivity growth should be allowed to adapt to this change with minimum interference. Similarly, when productivity growth is below average, the economy should adapt to that as well. In other words, if Kydland and Prescott are correct, many fluctuations in employment occur for good reasons, and we should be uneasy about policies that counteract those fluctuations. Thus, Kydland and Prescott's findings suggest that the Fed should retreat somewhat from a countercyclical monetary policy toward one that emphasizes other Fed goals, such as price stability.

While this suggestion has considerable force, one countervailing point needs to be kept in mind. Recall that the driving force in Kydland and Prescott's explanation of business cycles is the investment in producers' goods that takes place to exploit rising factor productivity. We know from a variety of evidence that the channelling of funds from investors to firms (for the purposes of financing investment) is fraught with hazards. These hazards account for institutional features of capital markets such as downpayment or equity positions, collateral, insurance, and third-party guarantees. In the presence of these difficulties in financing investment, can we be sure that an economy will adapt efficiently to growth in TFP? If not, countercyclical monetary policy may have a role in promoting efficient adaptation to changes in TFP.

To appreciate this point, consider how the requirement that a borrower offer adequate downpayment against a loan affects the transfer of funds from investors to firms. Suppose that a toy manufacturing firm would like to spend $2 million to expand its capacity. The plan involves building an addition to the exist-

ing plant and purchasing additional machinery. If investors knew as much about the toy business as the firm does, and if they were absolutely convinced that the owners and managers of the firm would be able and willing to repay any funds they borrowed, investors would simply lend the firm the $2 million to carry out the expansion. In reality, investors generally would not know enough about the expected profitability of the planned project, nor would they be absolutely certain about the abilities and integrity of the people borrowing the money. Therefore, investors need some assurance that the owners of the firm will use their borrowed funds wisely. One common way of obtaining assurance is to ask the firm to sink some of its own funds into the project so that its owners have a stake in the outcome. Therefore, the pace of investment is constrained by how much of a downpayment a firm can put toward its investment projects.

In a 1989 article, Ben Bernanke and Mark Gertler showed that changes in TFP could have bigger and longer-lasting effects on investment in plant and equipment (and on other macroeconomic variables, such as total output) because of downpayment requirements. The reason is that when TFP growth is above average, firms have higher profits and can put up more funds as a downpayment. Thus, both factors work toward quickening the pace of investment. Similarly, during periods of below-average growth in TFP, both factors work to constrain investment.

Bernanke and Gertler's point is that downpayment or equity position requirements make investment more responsive to TFP fluctuations than it would otherwise be. Furthermore, these requirements make plant and equipment investment sensitive to short-term interest rates too. For instance, by reducing the cost of carrying inventory, lower short-term interest rates can free up cash for meeting downpayment requirements on big-ticket investment projects. Thus, while downpayment or equity position requirements make investment overreact to fluctuations in TFP, they also make such investment sensitive to Fed-induced changes in short rates. Hence, Bernanke and Gertler's article hints at ways in which countercyclical monetary policy might have a role in promoting efficient responses to changes in TFP.

SUMMARY

Since the 1950s, economists have recognized that growth in the productivity of factors of production (such as labor and capital) is a primary source of economic growth in most developed countries. In 1982, Kydland and Prescott put forth the controversial view that *fluctuations* in productivity have been one of the main causes of business cycles in the United States since World War II. According to their most recent estimate, fluctuations in productivity growth may be responsible for as much as 70 percent of cyclical fluctuations in real GDP.

But measuring factor productivity is difficult, and we do not know for sure how much such productivity fluctuates. In particular, errors that creep into the measurement of labor inputs because official statistics report inputs purchased rather than the intensity of their use may exaggerate the extent of fluctuations in productivity and, therefore, the contribution of productivity fluctuations to business cycles.

However, if subsequent research vindicates Kydland and Prescott's estimates, some rethinking about the role of countercyclical monetary policy will be in order. Since Kydland and Prescott's findings suggest that business-cycle fluctuations occur for natural reasons, the Fed might consider giving less weight to stabilizing employment and more weight to other Fed goals, such as price stability.

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NOTICE

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