

Output Gaps: Uses and Limitations*

BY ROC ARMENTER

The concept of resource slack is central to understanding the dynamics between employment, output, and inflation. But what amount of slack is consistent with price stability? To answer this question, economists define baseline values for unemployment and output known as the natural rate of unemployment and potential output. The concepts of output and employment gaps can be useful to economists in several ways. First, they often guide the inflation forecasts of Federal Reserve staff and other researchers and market participants. Second, some economists argue that employment gaps are a useful guide for policy aimed at achieving maximum sustainable employment and price stability. In this article, Roc Armenter briefly discusses two important examples of sophisticated measures of resource slack that are grounded in economic theory: the nonaccelerating-inflation rate of unemployment and the output gap measure published quarterly by the Congressional Budget Office.

expand employment without having to raise wages to attract workers. Other measures of slack are the percentage of industrial capacity available or the ratio of inventories to sales.

It is unreasonable to expect all workers to be employed or industrial capacity to be at 100 percent. For example, unemployed workers will take the time to find the best job for them and perhaps may need time to relocate.

What amount of slack is consistent with price stability? To answer this question, economists define baseline values for unemployment and output known, respectively, as the natural rate of unemployment and potential output. These are the levels of employment and output consistent with the economy operating with stable prices. The output gap and employment gap are defined as the differences between the actual level for each variable and the baseline value. The actual level may be lower than the baseline level, and thus the output or employment gap can be negative.

The output and employment gap concepts can be useful to economists in several ways. First, output and employment gaps often guide the inflation forecasts of Federal Reserve staff, as well as those of researchers and market participants. For example, if the output gap is positive — that is, output is above its baseline level — firms will be operating close to full production capacity. Hence, firms will not be able to increase production further without significant investments. These investments are costly so it will take a while for firms to increase production. In the meantime,

Economists have greatly improved their understanding of the dynamics

between employment, output, and inflation since the 1970s. The concept of resource slack is central to these dynamics. For example, economists track the share of unemployed workers, allowing them to estimate how quickly firms may be able to



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firms will respond to increased demand by raising prices. Thus, positive output gaps can signal future inflationary pressures. Since monetary policy operates with significant lags, it is important that policymakers have an accurate inflation forecast.

Second, some economists argue that employment gaps are a useful guide for policy aimed at achieving maximum sustainable employment and price stability, which are the mandated objectives of monetary policy in the United States. Over the medium term, employment is driven by fundamentals such as productivity and labor supply growth, and these medium-term measures are used to infer simultaneously the natural rate of unemployment and the unemployment gap. Most economists do not think monetary policy is part of these medium-term fundamentals. Instead, attempts to drive employment or output above their fundamental levels would result in unwanted inflation and no employment gains.

Economists have developed sophisticated measures of resource slack that are grounded in economic theory, yet remain workable in practical terms. We will briefly discuss two important examples: the nonaccelerating inflation rate of unemployment (NAIRU) model and the output gap measure published quarterly by the Congressional Budget Office (CBO). However, even the latest models recognize that there is a large amount of uncertainty about output and employment gaps. Moreover, there remain competing definitions of the output and employment gaps. Alternative measures sometimes offer contrasting implications for monetary policy. Therefore, it is important to understand the limitations of current output gap estimates for both inflation forecasting and output stabilization.

MILTON FRIEDMAN AND THE NATURAL RATE OF UNEMPLOYMENT

Economists have long believed in a relationship between money, prices, and employment — some say since the 18th century!¹ However, it was not until 1958 that A.W. Phillips provided the first statistical analysis comparing wage inflation and unemployment, using data for the United Kingdom since 1861.² Phillips found that when unemployment was high, inflation was low. This negative relationship now bears

Nowadays economists recognize that the Phillips curve is more than a statistical relationship between two variables.

his name: the Phillips curve. A few years later Paul Samuelson and Robert Solow imported the Phillips curve to the United States.³ Samuelson and Solow used price inflation instead of wage inflation, a choice now preferred by most researchers. Figure 1 displays a typical Phillips curve plot for the period 1948-1965. Each dot corresponds to the inflation and unemployment rate during a quarter. The solid line displays the statistical relationship.

Nowadays economists recognize that the Phillips curve is more than a statistical relationship between two variables. The modern view of the Phillips curve is rooted in the ideas that Milton Friedman developed at the University of Chicago during the late 1960s.⁴ Friedman believed that

¹Robert Lucas, in his Nobel lecture, traced the observation back to the writings of David Hume.

²See the article by A.W. Phillips.

³See the study by Samuelson and Solow.

⁴For a detailed discussion of the so-called New Keynesian Phillips curve, see the article by Keith Sill on page 17.

attempts to increase employment by increasing inflation were misguided. Only unanticipated inflation, Friedman argued, has the ability to stimulate employment. For example, if households and firms expect an inflation rate of 2 percent, a 3 percent inflation rate would effectively increase output and employment by boosting real demand. However, as workers and firms came to expect a 3 percent inflation rate, they would embody such expectations in wage demands and price setting. As a result, an inflation of 3

percent would increase nominal output compared with 2 percent inflation, but since all prices and wages adjusted by 3 percent as well, there would be no change in real output and employment.

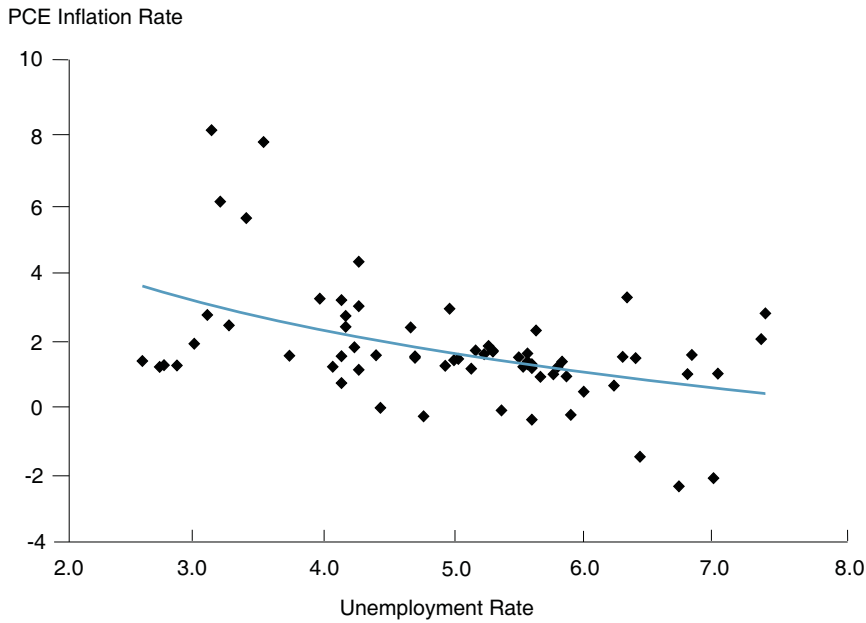
Friedman's view was validated when inflation rose persistently in the 1970s despite a marked slowdown in employment growth. Indeed, analysts coined the term stagflation to describe the combination of stagnant growth and inflation.

The old view of the Phillips curve could not explain the stagflation phenomenon. Figure 2 plots unemployment and inflation rates for the period 1970-1979. We include the Phillips curve as given in Figure 1 for the period 1948-1965. The actual observations are all northeast of the Phillips curve: Both inflation and unemployment rates were higher than the theory predicted. This was not immediately recognized, and many policymakers mistakenly believed that inflation would reverse course and moderate.⁵

⁵The book by Thomas Sargent discusses the experience of the 1970s in rich detail.

FIGURE 1

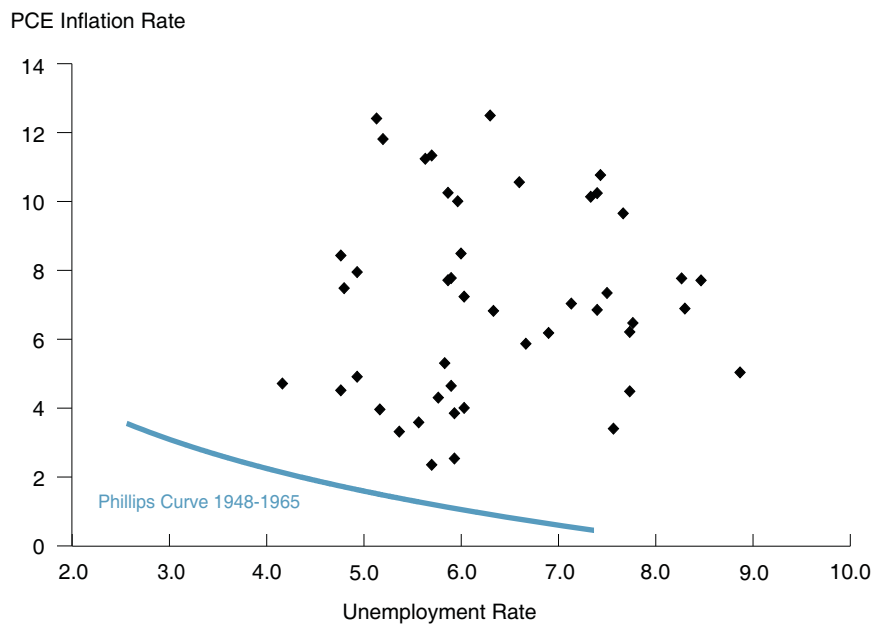
The Classical Phillips Curve 1948-1965



Quarterly data, 1948-1965, seasonally adjusted
Sources: BLS/Haver for unemployment rate; BEA/Haver for PCE inflation rate

FIGURE 2

Stagflation 1970-1979



Quarterly data, 1970-1979, seasonally adjusted
Sources: BLS/Haver for unemployment rate; BEA/Haver for PCE inflation rate

(See Did Oil Prices Cause the Inflation in the 1970s?)

Friedman defined a baseline value for employment in his theory and thus postulated employment gaps as we know them today. The so-called natural rate of unemployment is the rate we would observe if inflation were exactly as expected. This definition is mainly theoretical, but, as we shall see later, some current measures of employment gaps are inspired by this definition.

Friedman's view came with some key policy "lessons" that would be learned the hard way. First, attempts to exploit the Phillips curve would bring about lower unemployment temporarily at best; further increases in the money supply would be met by rising inflation. Second, in order to be able to stabilize output in the short term without causing rising inflation, policymakers need to know what the natural rate of unemployment is. Friedman himself was deeply skeptical that this could be done effectively. To do so, policymakers would need to accurately forecast the state of the economy. Finally, Friedman's analysis highlighted the importance of inflation expectations in achieving price stabilization. Nowadays central banks around the world realize that any attempt to exploit the trade-off between inflation and employment will be short-lived, at best. Thus, central bank policy emphasizes price stabilization in order to anchor inflation expectations.⁶

SOME OUTPUT AND EMPLOYMENT GAP MEASURES

Currently, there is an array of statistical procedures to approximate the natural rate of unemployment or its

⁶The study by Jeffrey Lacker and John Weinberg contains further discussion of the Phillips curve and the research on inflation and unemployment.

Did Oil Prices Cause the Inflation in the 1970s?

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wice in the 1970s the price of oil soared. The first oil crisis started in October 1973 when the Organization of the Petroleum Exporting Countries (OPEC) declared it would stop oil shipments to the United States. Oil prices tripled in a year. The second oil crisis occurred in 1979 as a result of the Iranian revolution. Although some OPEC countries increased their production, oil prices more than doubled. The United States would have to wait until 1986 to see oil prices drop below \$20 again.

Some of the most dramatic inflation rates recorded were associated with these oil crises. However, oil prices alone cannot explain the extraordinary behavior of prices and employment in the 1970s. First, the increase in the inflation rate was noticeable well before 1973, while oil prices remained low. The figure plots the inflation rate (left axis) and the oil-price level (right axis). By 1970,

inflation was above 4 percent and never dropped below 3 percent. Meanwhile, oil prices were completely flat.

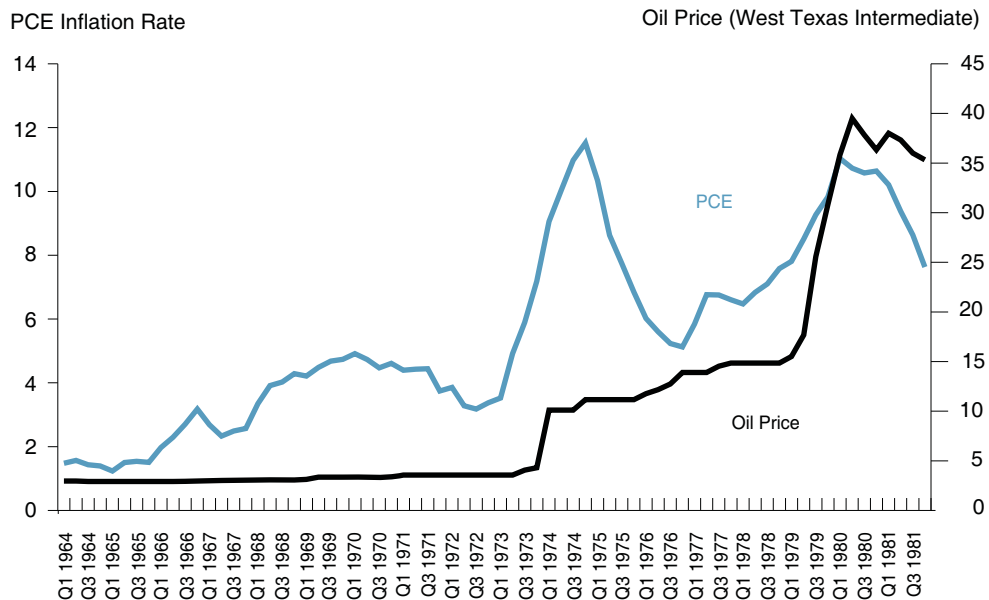
Second, the crises of 1973 and 1979 were one-time price increases. As such, they can explain only temporary increases in inflation, for example, the spike in the inflation rate in 1974. However, one-time price increases cannot explain the persistent rise in inflation that is evident in the figure.* Inflation was close to 8 percent in 1978, five years after the oil crisis.

Finally, inflation was widespread. Oil prices clearly affected the price of gas, transportation, and some other goods that use oil in their production. But oil prices should have only a small impact on other goods, such as food or apparel. Yet these goods also showed persistent inflationary behavior.

For further reading on oil prices and economic activity, see the *Business Review* article by Sylvain Leduc and the one by Keith Sill.

FIGURE

Oil Prices and Inflation in the 1970s



Quarterly data, 1964-1981

Sources: BEA/Haver for PCE inflation rate; Wall Street Journal/Haver for oil prices

* Cost increases, such as the oil shock, take some time to pass through to consumer prices. However, the rise in inflation was too large and, more important, too prolonged for any reasonable estimate of pass-through.

equivalent concept in terms of GDP: potential output. There are many differences across these measures. For example, some models are evaluated monthly, others quarterly. Models also often differ in the variables taken into consideration. However, all of the gap measures discussed here share two defining properties. First, baseline levels are defined by their neutral stance on inflation; that is, they all try to measure the level of output or employment consistent with price stability. Second, researchers assume that the natural rate and potential output move slowly; that is, their determinants (such as labor supply) operate exclusively in the medium to long term.

We will now briefly discuss two leading models for employment and output gaps, respectively.

The NAIRU. The very name of the NAIRU — the nonaccelerating-inflation rate of unemployment — spells out the model. The NAIRU is the level of unemployment consistent with inflation behaving as expected. In the model, researchers also specify how inflation and unemployment are related in the short term.

The NAIRU closely tracks Friedman’s ideas. In this model, expected inflation is usually given by an average of past inflation rates. The idea is that firms and households create their inflation expectations on the basis of their recent experience with prices. If inflation is unexpectedly high in one period, it will drive unemployment down, but it will also drive inflation expectations up, as the average of past inflation rates increases accordingly. If inflation stays at the same high rate, the effect on unemployment will be less. Hence the trade-off between inflation and unemployment is necessarily short-lived.

NAIRU models regularly incorporate information about real factors,

such as commodity prices, that may affect unemployment or inflation in the short run. Newer NAIRU models allow the natural rate of unemployment to vary over time.⁷ The fluctuations in the natural rate of unemployment, though, are assumed to be slow moving and very persistent. The assumption mostly conforms to our intuition. For example, the natural rate of unemployment reflects long-term changes in labor productivity growth, brought about by the introduction of new technologies.

Figure 3 plots the unemployment rate and an estimate of the NAIRU for the period 1949-2005. The NAIRU increased in the 1970s and fell for most of the 1990s. However, the NAIRU is much smoother than the actual

unemployment rate, capturing only the persistent swings in the data. The flip side, as shown in Figure 3, is that the employment gap — the difference between the NAIRU and the unemployment rate — is relatively short-lived; that is, it does not stay positive or negative for long periods of time.

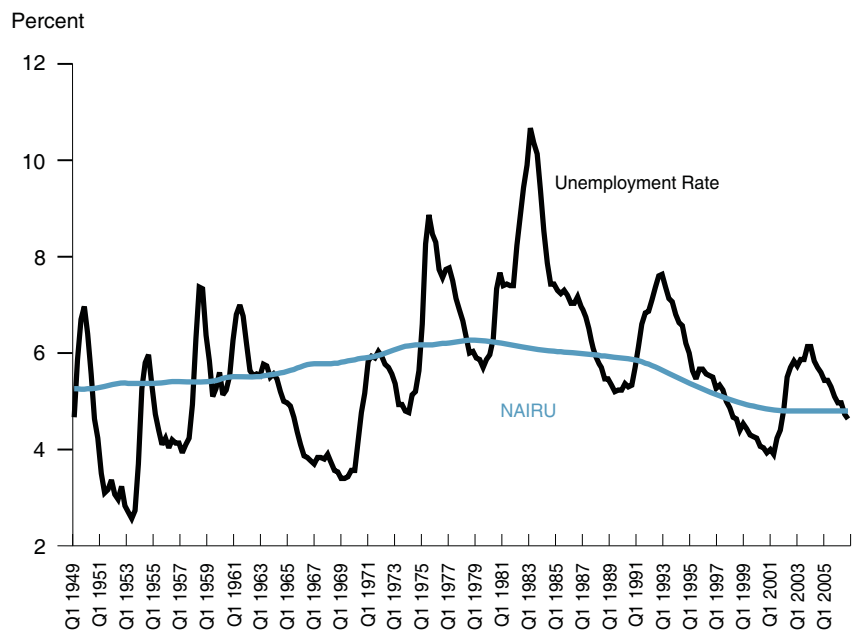
CBO Output Gap. The Congressional Budget Office (CBO) publishes a quarterly estimate of potential output that is a key input to the fiscal policy outlook and is widely tracked by professional forecasters. The CBO defines potential output as the level of output that is neither adding to nor subtracting from inflationary pressures. Thus, it is an equivalent concept to the NAIRU in terms of output rather than employment.

Because of its focus on fiscal policy, the CBO is interested in forecasting output in the medium term in addition to inflation. The longer horizon forecast is needed in order to evaluate

⁷For an overview of NAIRU models, see the 1997 study by Douglas Staiger, James Stock, and Mark Watson.

FIGURE 3

NAIRU and the Unemployment Rate



Quarterly data, 1949-2005

Sources: BLS/Haver for unemployment rate; Haver for NAIRU

the fiscal cost of different programs and the debt and tax changes needed to finance them. To this end, the CBO makes an effort to incorporate additional information into its computation of potential output. For example, the CBO pays special attention to demographic and educational trends. These trends are important for forecasting the labor supply over the next five to 10 years, but they are unlikely to affect inflation.

The CBO uses a production function approach to track gross domestic product.⁸ The production function is very good for combining diverse data sources. For example, the CBO uses data on labor supply, capital utilization rates, industrial capacity, and electricity consumption. Researchers then break down these data series into transitory and persistent components; then the latter is used to construct the estimate of potential output. A key input in the estimate is productivity or, more broadly speaking, technology. For this the CBO must rely on estimates of worker productivity and judgment calls. And, once again, the assumption is that these fundamentals are slow moving.⁹

Figure 4 plots the output gap series, as computed by the CBO, for the period 1956-2009. Whenever the output gap is positive, the economy is running above potential — for example, in the second half of the 1990s. In contrast, the economy was below potential for most of the 1970s and early 1980s, as well as in 2009. With some exceptions, output gaps close quite fast, meaning the economy reverts to the path of potential output.

⁸ A production function states a relationship between inputs (like labor and capital) and output (goods and services combined).

⁹ For further reading on the computation of the CBO output gap, see the background paper published by the CBO.

RECENT DEVELOPMENTS

Economists continue to work on models of potential output and the natural rate of unemployment. Newer models seek a more flexible specification of potential output, allowing for short-term fluctuations, or incorporate additional variables in the specification, such as interest rates or aggregate consumption.

The second half of the 1990s also presented a challenge. As in the 1970s, the observed inflation and unemployment rates did not square with existing models. This time, though, the situation was the opposite and thus more benign: Output and employment growth were high, yet inflation remained low and stable. Figure 5 plots the output gap, as computed by the CBO, and inflation, computed from personal consumption expenditures (PCE), for the second half of the 1990s. The output gap turned positive

in early 1996 and became very large by the end of the decade, as one can see from Figure 5 as well. Not only was the output gap large, but, by 2000, it had not shown any signs of moderation. In this context, many economic models would predict that inflation would rise sharply. Yet inflation actually declined from 1996 to 1998, as can also be seen in Figure 5. Only in 1998 and 1999 did inflation show a very modest pick-up.¹⁰

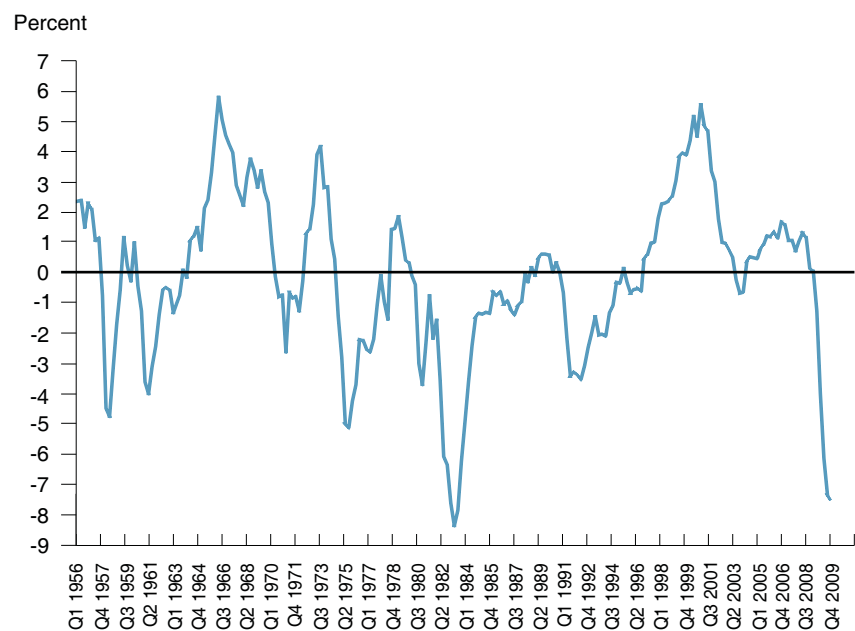
SHORTCOMINGS OF STATISTICAL GAPS

Despite the sophistication of these models, it turns out that they are limited in their ability to forecast inflation in the short term. It is important to understand the limitations of the use-

¹⁰ The 2002 study by Staiger, Stock, and Watson contains an extensive discussion of the experience in the 1990s for NAIRU models.

FIGURE 4

Output Gap



Quarterly data, 1956-2009
Sources: CBO/Haver

fulness of output and employment gaps as a guide for setting monetary policy.

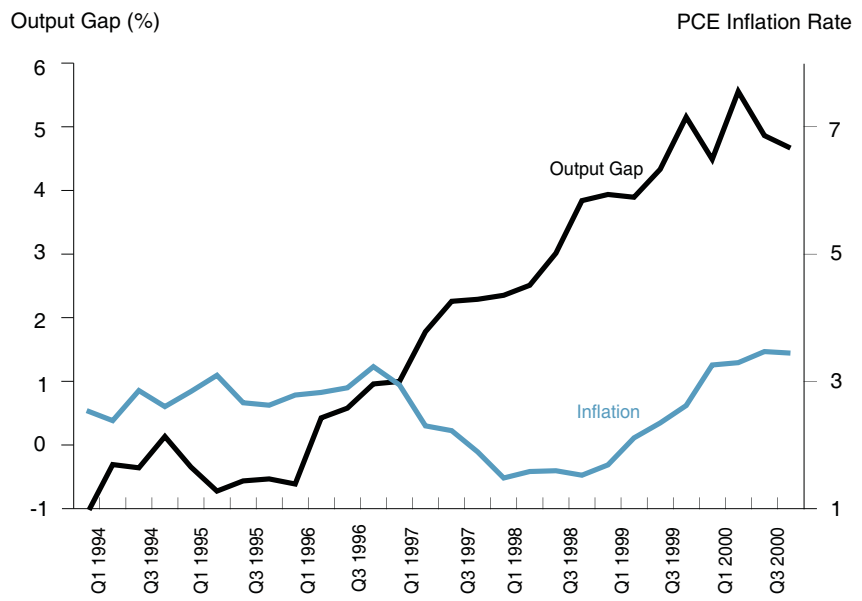
The first set of shortcomings of statistical models involves the data. Most macroeconomic data are released with a significant lag and are subject to revision. Moreover, forecasts must rely on the most recent releases, which are indeed the most likely to be revised. This is often known as the “end-of-sample” problem, and there is little researchers can do about it. For example, models that use GDP data must always rely on the Bureau of Economic Analysis’ (BEA) “advance” estimate for the last quarter, which is usually heavily revised.¹¹

Another shortcoming arises from the assumption that estimates of potential output and the natural rate of unemployment move smoothly. While we usually view the technology diffusion process as slow and smooth, some factors can have a sudden impact on supply. For example, extreme weather conditions can lead to the disruption of services and, in some cases, have a very persistent effect. More important, this assumption implies that fluctuations in output or unemployment are always initially counted as changes in the gap, not as changes in potential output or the natural rate of unemployment. In more technical terms, errors in the short-term forecast of output or employment gaps accumulate, and it takes a while before these errors are corrected. For example, say a new technology brings a significant improvement in productivity and thus simultaneously increases potential and actual output. Because researchers

¹¹ Advanced models are careful to use real-time data. The Real-Time Data Research Center at the Federal Reserve Bank of Philadelphia has developed a real-time data set for macroeconomists, available at <http://www.philadelphiafed.org/research-and-data/real-time-center/real-time-data/>.

FIGURE 5

Output and Inflation in the 1990s



Quarterly data, 1994-2000
Sources: CBO/Haver for output gap; BEA/Haver for PCE inflation

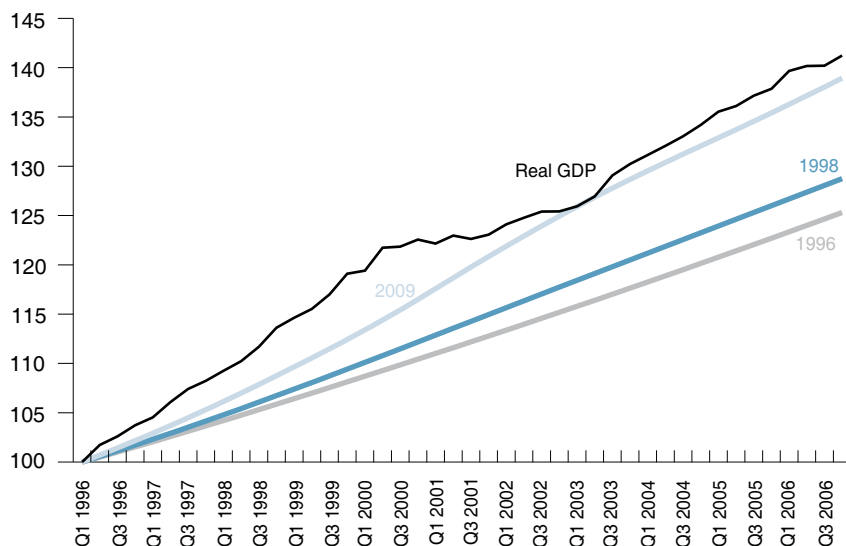
do not observe productivity directly, the increase in output will be initially viewed as a temporary deviation and ascribed to an increase in the output gap. Only when researchers observe that the higher output level persists over the medium term will the estimate of potential output be updated.

We return to the experience of the second half of the 1990s for a real-life example regarding estimates of potential output. Figure 6 plots (in black) the level of real GDP from 1996 to 2006, with the level normalized to 100 in 1996. As mentioned earlier, this was a period of rapid and persistent economic growth: Real GDP grew 20 percent in four years. Let us see how estimates of potential output caught up with the experience. The gray line in Figure 6 plots the estimates of potential output provided by the CBO in 1996; they are thus a forecast for the period. The dark blue line reports the estimates of potential output at the

end of 1998. After three years of actual data pointing to strong GDP growth, economists barely nudged up their estimates of potential output.¹² In other words, the model suggested a huge output gap. Finally, the light blue line plots the latest estimates of potential output. Economists now recognize that most of the growth in the second half of the 1990s was due to fundamentals: Estimates of potential output track real GDP much more closely than the initial estimates.

There are also reasons to think that the statistical relationship between inflation and output varies over time. Policymakers are aware of this and often have additional information about the likely path of infla-

¹² This is a problem common to all statistical models: It is difficult to distinguish temporary from permanent fluctuations at the end of the sample.

FIGURE 6**GDP and Potential Output Estimates**


Quarterly data, all series set equal to 100 in 1996
 Sources: CBO for potential output estimates; BEA/Haver for real GDP

tion or output that cannot be readily quantified. Statistical models provide little guidance on how to modify the resulting estimates in order to incorporate the additional information. For example, the current downturn has

affected the manufacturing and construction sectors disproportionately. It is clear that some workers will have to find jobs in new sectors, and this will take some additional time. The natural rate of unemployment will have to be

adjusted upward at least for a time to account for the reallocation. However, the statistical models do not contain a breakdown by sector, and thus it is not clear how to modify the model's estimates.

CONCLUSION

We have seen how economists have developed the concepts of output and employment gaps as key tools for understanding the long-term movements in unemployment and output. These long-term measures are often used to provide information on economic activity relative to trend and thus help us gauge how relatively strong or weak current economic activity is. Understandably, such knowledge is often important for implementing economic policies.¹³ However, as this article has shown, measures of the NAIRU and potential output are subject to severe measurement problems that detract from their application. Therefore, it is important that we understand their limitations. 

¹³The article by Anthony Santomero discusses how the availability and reliability of economic information affects policymaking.

REFERENCES

Congressional Budget Office. "A Summary of Alternative Methods for Estimating Potential GDP," Background Paper (March 2004).

Lacker, Jeffrey, and John A. Weinberg. "Inflation and Unemployment," Federal Reserve Bank of Richmond, Annual Report (2006).

Leduc, Sylvain. "Oil Prices Strike Back," Federal Reserve Bank of Philadelphia, *Business Review* (First Quarter 2001), pp. 21-30.

Lucas, Robert. "Monetary Neutrality," Nobel Prize lecture, December 7, 1995, available at: http://nobelprize.org/nobel_prizes/economics/laureates/1995/lucas-lecture.pdf.

Phillips, A. W. "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957," *Economica*, 25:100 (1958), pp. 283-99.

Samuelson, Paul A., and Robert M. Solow. "Analytical Aspects of Anti-Inflation Policy," *American Economic Review*, 50:2 (1960), pp. 177-94.

Santomero, Anthony M. "Making Monetary Policy: What Do We Know and When Do We Know It?" Federal Reserve Bank of Philadelphia *Business Review* (Fourth Quarter 2005), pp. 1-8.

Sargent, Thomas J. *The Conquest of American Inflation*. Princeton: Princeton University Press, 2001.

Sill, Keith. "The Macroeconomics of Oil Shocks," Federal Reserve Bank of Philadelphia, *Business Review* (First Quarter 2007), pp. 21-31.

Sill, Keith. "Inflation Dynamics and the New Keynesian Phillips Curve," Federal Reserve Bank of Philadelphia *Business Review* (First Quarter 2011).

Staiger, Douglas, James H. Stock, and Mark Watson. "The NAIRU, Unemployment, and Monetary Policy," *Journal of Economic Perspectives*, 11:1 (1997), pp. 33-49.

Staiger, Douglas, James H. Stock, and Mark Watson. "Prices, Wages, and the U.S. NAIRU in the 1990s," in Alan Krueger and Robert Solow, eds., *The Roaring Nineties*. Russell Sage Foundation, New York, 2002.