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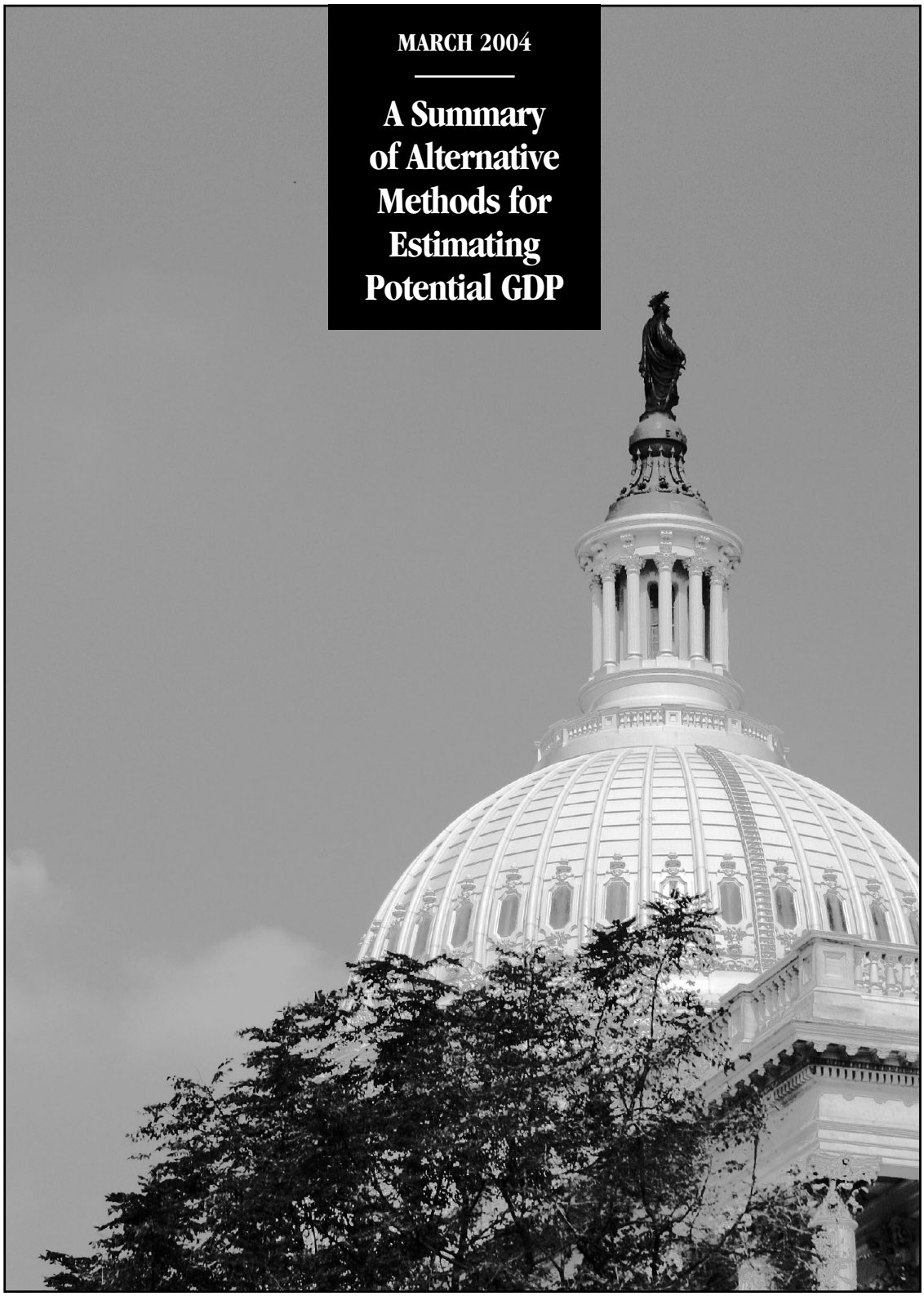
PAPER

MARCH 2004

A Summary of Alternative Methods for Estimating Potential GDP



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The Congress of the United States ■ Congressional Budget Office

Notes

In the figures in this paper, the shaded vertical bars indicate periods of recession.

Unless otherwise indicated, all years referred to in this paper are calendar years.

Preface

For the Congressional Budget Office (CBO), estimating the potential output of the economy and projecting future levels of that output are integral parts of producing short-term economic forecasts and medium-term economic projections. Potential output is an estimate of "full-employment" gross domestic product, or the level of GDP attainable when the economy is operating at a high rate of resource use. Rather than being a technical ceiling on production, potential GDP is a measure of the economy's maximum sustainable output, in which the intensity of resource use is neither adding to nor subtracting from inflationary pressure. There are many ways to compute the economy's productive potential. Some methods rely on purely statistical techniques. Others—including CBO's method—rely on statistical procedures grounded in economic theory.

This paper examines those methods, highlighting the pros and cons of various approaches. In CBO's view, its method—which calculates potential GDP using a growth model—provides an appropriate balance of advantages and disadvantages and offers the best structure for projecting GDP. CBO's basic procedure remains the same as that outlined in previous reports, although the agency will continue to examine alternative procedures.

Robert Arnold of CBO's Macroeconomic Analysis Division wrote this paper, with assistance from Robert Dennis and John Peterson. Christian Spoor edited the paper, and Leah Mazade proofread it. Maureen Costantino took the cover photograph and prepared the paper for publication. Annette Kalicki prepared the electronic versions for CBO's Web site (www.cbo.gov).

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Director

March 2004

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A Summary of Alternative Methods for Estimating Potential GDP

Introduction

Assessing current economic conditions, gauging inflationary pressure, and projecting long-term economic growth are central aspects of producing the Congressional Budget Office's (CBO's) economic forecasts and baseline budget projections. Those tasks require having a summary measure of the economy's productive capacity. That measure—known as potential output—is an estimate of "full-employment" gross domestic product, or the level of GDP attainable when the economy is operating at a high rate of resource use.

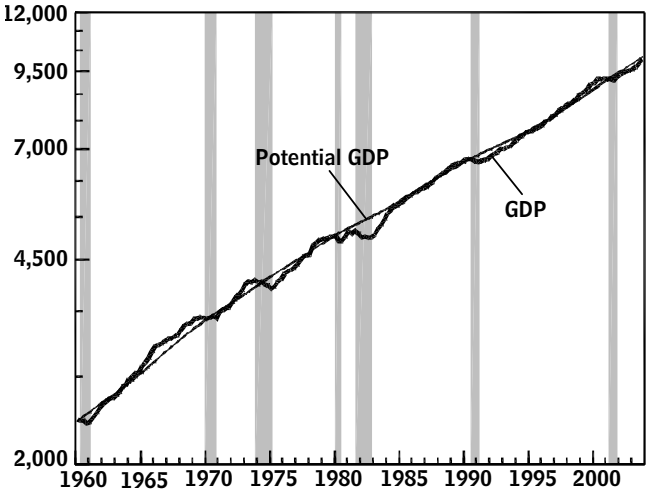
Although potential output measures the productive capacity of the economy, it is not a technical ceiling on output that cannot be exceeded. Rather, it is a measure of sustainable output, in which the intensity of resource use is neither adding to nor subtracting from inflationary pressure. If actual output exceeds its potential level, then constraints on capacity begin to bind, restraining further growth and contributing to inflationary pressure. If output falls below potential, then resources are lying idle and inflation tends to fall.

Besides being a measure of aggregate supply in the economy, potential output is also an estimate of trend GDP. The long-term trend in real (inflation-adjusted) GDP is generally upward (see Figure 1) as more resources—primarily labor and capital—become available and as technological change allows more-efficient use of existing resources. Real GDP also displays short-term variation around that long-term trend—largely because of the influence of the business cycle but also because of random shocks whose sources are difficult to pinpoint. Analysts often want to estimate the underlying trend, or general momentum, in GDP by removing such short-term variation. A separate but related objective is to remove the fluctuations that arise solely from the effects of the business cycle. Potential GDP serves both purposes.

Figure 1.

GDP and Potential GDP

(Billions of chained 2000 dollars)



Source: Congressional Budget Office.

Note: The y axis is plotted using a logarithmic scale.

Potential output plays a role in several aspects of CBO's economic forecast. In particular, CBO uses potential output to set the level of real GDP in its medium-term (10-year) projections. In doing so, CBO assumes that any gap between actual GDP and potential GDP that remains at the end of the short-term (two-year) forecast will close during the following eight years. CBO also uses the level of potential output to gauge inflationary pressure in the near term. For example, an increase in inflation that occurs when real GDP is below its potential (and monetary growth is moderate) can probably be attributed to temporary factors and is unlikely to persist. Finally, potential output is an important input in computing the standard-

ized-budget surplus or deficit, which CBO uses to evaluate the stance of fiscal policy.[1]

There are many ways to estimate the trend in GDP (and other economic data) as well as to compute the economy's productive potential. Some methods rely on purely statistical techniques. Others, such as CBO's method, rely on models guided by economic theory. Many methods used to compute potential output do not benchmark their trends to inflation or any independent measure of capacity and therefore cannot be interpreted as estimating the level of maximum sustainable output. That is, they provide a measure of *trend* output but not *potential* output.

Measures of potential GDP were initially devised to guide decisions about monetary and fiscal policy, generally for a one- to two-year horizon. If the economy was estimated to be below potential—meaning that labor or capital was not fully employed—then monetary or fiscal policy could be used to speed up the growth of output without incurring the risk of significantly higher inflation. The concept of potential output was seen as a tool to help policymakers manage aggregate demand and thus maintain steady economic growth.

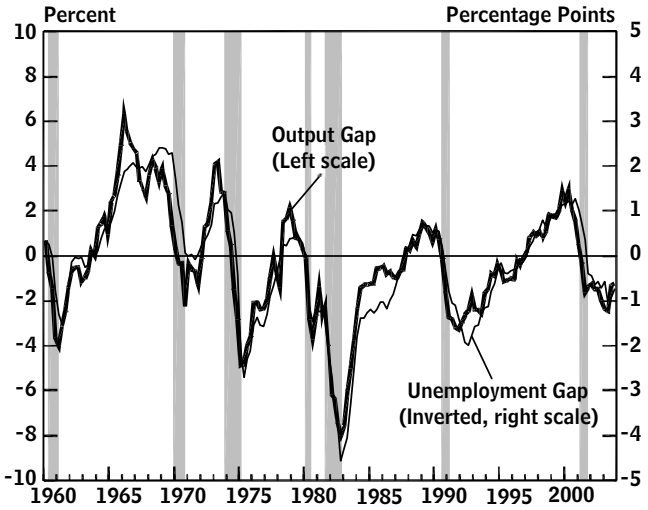
A spectrum of opinion exists among economists about the usefulness of measures of potential GDP for monetary and fiscal policy and for economic projections. Some economists do not think that the idea of potential output is useful, arguing that:

- The concept is based on a flawed view of the causes of inflation, even in the short run. According to this argument, inflation is determined by growth in the money supply, not by where the economy is in the business cycle.
- Potential GDP is so unstable and varies so much that it is impossible to estimate accurately, especially for recent years, and thus is not a helpful guide for policymaking or forecasting.
- Policies to manage demand generally do more harm than good because of lags, uncertainties, and political pressures. Hence, the size of the gap between actual and potential output ought to be irrelevant to policymakers.

1. See Congressional Budget Office, *The Cyclically Adjusted and Standardized-Budget Measures* (March 2004).

Figure 2.

Okun's Law: The Output Gap and the Unemployment Gap



Source: Congressional Budget Office.

The experience of the late 1990s supported the position of people making those arguments, because virtually all initial estimates of potential GDP indicated a need for tighter policy to avoid inflation, but higher inflation never materialized. More-recent experience, however, has tended to support the opposite opinion: the fiscal and monetary policies put in place in response to the 2001 recession and its aftermath—which were predicated on the view that demand had fallen below its potential—appear to have been timely and to have helped moderate the downturn.

In CBO's view, the value of potential GDP is not restricted to short-term fiscal and monetary policy. Potential output calculated with a growth model is a useful concept for gauging the economy's productive capacity and offers the best basis for projecting GDP over the 10-year horizon required by the budget process. Carefully estimated, potential GDP can provide the user with a reasonable sense of the economy's potential for growth.

Any estimate of potential output, however, has shortcomings of which users should be aware. First, such estimates are based on one or more statistical relationships and thus contain an element of randomness. The uncertainty surrounding an estimate of potential GDP can be reduced—but not eliminated. Second, all of the methods used to compute potential GDP have an "end-of-sample" problem. That is, estimating the trend in a data series is espe-

cially difficult near the end of a data sample, making the estimate most uncertain for the period of greatest interest: the recent past. Third, all economic data are subject to revision, and data for recent history are subject to the largest revisions.

CBO's Method for Estimating Potential Output

CBO's estimate of potential output is based on the framework of a textbook model of long-term economic growth, the Solow growth model.[2] The model attributes the growth of real GDP to the growth of labor (hours worked), capital (an index of capital services emanating from the stock of productive assets), and technological progress (total factor productivity). CBO estimates trends —that is, removes the cyclical changes—in the labor and productivity components by using a variant of a relationship known as Okun's law. (In principle, other "detrending" methods could be used to extract the trends in those inputs.)

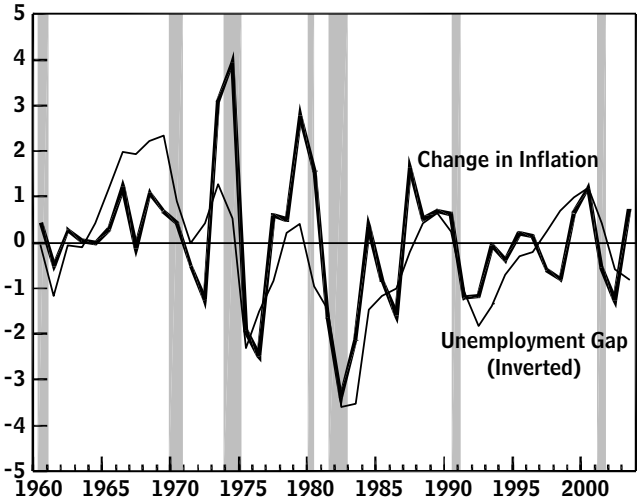
Okun's law postulates an inverse relationship between the size of the output gap (the percentage difference between GDP and potential GDP) and the size of the unemployment gap (the difference between the unemployment rate and the natural rate of unemployment) (see Figure 2).[3] According to that relationship, actual output exceeds its potential level when the rate of unemployment is below the "natural" rate of unemployment; actual GDP falls short of potential when the unemployment rate is above its natural rate.

For the natural rate of unemployment, CBO uses its estimate of the nonaccelerating inflation rate of unemployment (NAIRU).[4] That rate corresponds to a particular notion of full employment—the rate of unemployment

Figure 3.

The Unemployment Gap and the Change in Inflation

(Percentage points)



Source: Congressional Budget Office.

Notes: Inflation is measured using the consumer price index for all urban consumers.

Unlike the other figures in this report, this figure uses annual data.

that is consistent with a stable rate of inflation. The historical estimate of the NAIRU derives from an estimated relationship known as a Phillips curve, which connects the change in inflation to the unemployment rate and other variables, including changes in productivity trends, oil price shocks, and wage and price controls. The historical relationship between the unemployment gap and the change in the rate of inflation is strong (see Figure 3) and fairly stable. When the unemployment rate is below the NAIRU, inflation tends to rise, and when it exceeds the NAIRU, inflation tends to fall.

CBO estimates an Okun's Law relationship for hours worked and total factor productivity (TFP). It uses regression equations that link each variable to the same set of explanatory variables (including the unemployment gap) to capture the effects of fluctuations in the business cycle. It also uses several time trends, which constrain the growth of the potential variables to a constant rate over one or more specified historical periods. CBO then calculates the potential levels of hours worked and TFP from the predictions of the equations when the unemployment

2. See Congressional Budget Office, *CBO's Method for Estimating Potential Output: An Update* (August 2001).

3. The natural rate of unemployment is the rate of unemployment that prevails when the labor market is in equilibrium and the only source of unemployment is job turnover (workers shifting between jobs and searching for new jobs).

4. For a description of CBO's procedure for estimating the NAIRU, see Congressional Budget Office, *The Economic and Budget Outlook: An Update* (August 1994), Appendix B. See also Congressional Budget Office, *The Effect of Changes in Labor Markets on the Natural Rate of Unemployment* (April 2002).

gap is set at zero. Those potential levels are combined with the capital input to compute potential GDP.[5]

Unlike the labor input and TFP, the capital input does not need to be cyclically adjusted to create a "potential" level—the unadjusted capital input already represents its potential contribution to output. Although use of the capital stock varies greatly during the business cycle, the potential flow of capital services will always be related to the total size of the capital stock, not to the amount currently being used.

Other Methods for Estimating Potential Output

CBO's approach is just one of a host of methods available for estimating potential GDP, each of which has strengths and weaknesses. The major methods include:

- *Labor productivity growth accounting.* This approach is similar to CBO's method except that it models potential output as a function of labor and labor productivity.[6] This approach is simpler than CBO's approach because it avoids the need to estimate and project the capital input. It is favored by people who believe that capital is impossible to measure accurately. The inputs (labor and labor productivity) can be cyclically adjusted by using Okun's law or another detrending method.
- *Statistical filtering techniques.* Statistical filters (such as centered moving averages, bandpass filters, the Hodrick-Prescott filter, and the Kalman filter) are often used to extract the trend from GDP directly.[7] These methods do not generally use Okun's law and do not require judgments about trend breaks. However, they do require analysts to make assumptions about how the filters are structured, including the values of one or more parameters.
- *Simultaneous econometric models.* Some researchers have specified full simultaneous systems of equations that describe the behavior of variables such as output, employment, productivity, and inflation.[8] The parameters of these equations can be estimated using statistical techniques, and under certain assumptions, the equations can be used to calculate potential output.
- *Multivariate time-series models.* This category includes statistical methods of estimation known as vector autoregressions (VARs) and structural VARs.[9] These models are similar to the econometric models described above in that they estimate the parameters of econometric equations using statistical techniques. However, they differ in that they impose far fewer restrictions on the structure of, and relationships between, equations in the system than the econometric models do.

5. That method requires CBO to make judgments about when breaks occur in the trends for growth in TFP and hours worked. CBO allows those trends to change at business-cycle peaks. Note that the method does not force the trends to change at each peak; if the data do not call for a change, the trends will remain constant.

6. See, for example, George Kahn, "New Estimates of the U.S. Economy's Potential Growth Rate," *Contemporary Economic Policy*, vol. 14 (October 1996).

7. For examples of various statistical filters, see Mark French, *Estimating Changes in Trend Growth of Total Factor Productivity: Kalman and H-P Filters versus a Markov-Switching Framework,* Working Paper (Board of Governors of the Federal Reserve System, September 2001); Kenneth Kuttner, "Estimating Potential Output as a Latent Variable," *Journal of Business and Economic Statistics*, vol. 12, no. 3 (July 1994); Jane Haltmaier, *Inflation-Adjusted Potential Output,* International Finance Discussion Paper No. 561 (Board of Governors of the Federal Reserve System, August 1996); and Douglas Laxton and Robert Tetlow, *A Simple Multivariate Filter for the Measurement of Potential Output,* Technical Report No. 59 (Ottawa: Bank of Canada, June 1992).

8. See Charles Adams and David Coe, "A Systems Approach to Estimating the Natural Rate of Unemployment and Potential Output for the United States," *IMF Staff Papers,* vol. 37, no. 2 (June 1990).

9. For examples using this approach, see Ufuk Demiroglu and Matthew Salomon, *Using Time-Series Models to Project Output Over the Medium Term,* Technical Paper 2002-1 (September 2002), available at www.cbo.gov/Tech.cfm; Olivier Jean Blanchard and Danny Quah, "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review,* vol. 79, no. 4 (September 1989); Chantal Dupasquier, Alain Guay, and Pierre St-Amant, *A Comparison of Alternative Methodologies for Estimating Potential Output and the Output Gap,* Working Paper 97-5 (Ottawa: Bank of Canada, February 1997); and Pierre St-Amant and Simon Van Norden, *Measurement of the Output Gap: A Discussion of Recent Research at the Bank of Canada,* Technical Report No. 79 (Ottawa: Bank of Canada, August 1997).

Advantages and Disadvantages of the Different Methods

The first two approaches—CBO's method and the labor productivity growth accounting method—have several key advantages. First, they look explicitly at the supply side of the economy. Potential output is a measure of productive capacity, so any estimate of it is likely to benefit from explicit dependence on factors of production. For example, if growth in the available pool of labor increases, then both of those methods will show an acceleration in potential output (all other things being equal). Under CBO's approach, an increase in investment spending would also be reflected in faster growth in productive capacity.

Second, both of those methods permit a transparent accounting for the sources of growth. In other words, they allow analysts to divide the growth of actual or potential GDP into the contributions made by each of the factor inputs. For CBO's model, that means labor, capital, and TFP; for the labor productivity model, it means labor and labor productivity.

Third, by using a disaggregated approach, those two methods (particularly CBO's procedure) can reveal more insights about the economy than a more aggregated model would. For example, CBO's model allows analysts to identify the separate contributions made by hours worked, the stock of productive assets, and total factor productivity to the robust growth of potential GDP during the late 1990s. By looking at the different contributions, CBO determined that investment by businesses (especially in information technology) was the primary source of the acceleration in growth of potential output.

CBO's growth model and the labor productivity accounting method have disadvantages as well. The simplicity of those two approaches can be a drawback at times. CBO's model imposes some parameters—most notably, the weights on labor and capital in the production function—rather than estimating them econometrically. Although that approach is standard in the growth-accounting literature, it requires making some strong assumptions that may not be consistent with the data.

Another point of contention—particularly regarding CBO's approach—is the use of deterministic time trends to cyclically adjust many variables in the model. Some analysts assert that relying on fixed time trends provides a misleading view of the cyclical behavior of some economic time series. They argue, on the basis of empirical studies of the business cycle, that using variable rather than fixed time trends is more appropriate for most data series.

Finally, both CBO's growth model and the labor productivity accounting approach are based on an estimate of the amount of slack in the labor market, which in turn requires an estimate of the natural rate of unemployment or the NAIRU. Such estimates are highly uncertain. Few economists would claim that they can confidently identify the current NAIRU to within a percentage point. CBO's method and the labor productivity accounting approach are not very sensitive to possible errors in the average level of the estimated NAIRU, but they are quite sensitive to errors in identifying how that level changes from year to year.

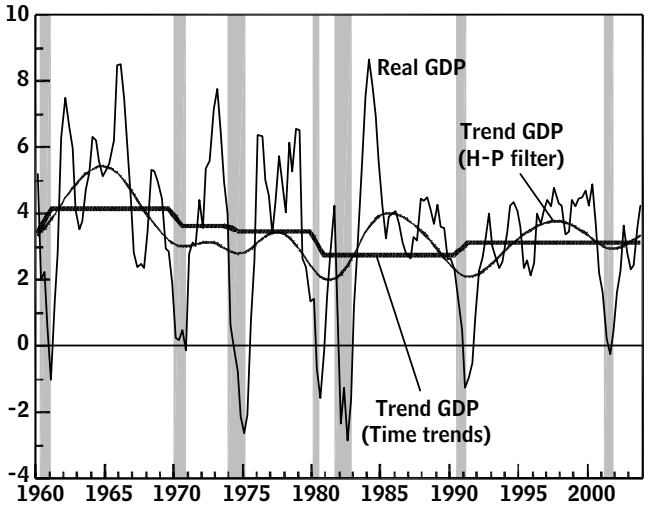
The three statistical approaches—statistical filtering, simultaneous econometric models, and multivariate time-series models—have a key advantage in that they are more flexible than the other methods in how they estimate the trends in the data series and the values of parameters. The filtering techniques, for example, do not require any judgments about when trend growth changes during the sample. Because they follow the data more closely, those methods tend to identify changes in trends more quickly (see Figure 4). The econometric-model and time-series-model approaches allow the data to determine the strength of the relationships among variables and equations within the model. The three statistical approaches also allow the values of estimated parameters to change as the economy evolves.

The statistical approaches also have their drawbacks. For the filtering methods, three shortcomings are significant. First, many of the filters do not benchmark their trends to any external measure of capacity. Therefore, unlike CBO's results, their results can be interpreted as *trend* GDP but not as *potential* GDP. In other words, they do not yield an estimate of the level of output that is consistent with stable inflation. Moreover, the filtering methods do not produce cyclically adjusted estimates of GDP, meaning that they do not attempt to remove the effects of business-cycle fluctuations from the variable being filtered. For example, a filtered estimate of real GDP slows considerably during each recession and accelerates afterward (see Figure 4). A cyclically adjusted measure of trend GDP would not display that type of cyclical fluctuation.

Figure 4.

Growth in Real GDP and Trend Growth Computed Using Deterministic Time Trends and the Hodrick-Prescott Filter

(Percentage change from previous year)



Source: Congressional Budget Office.

Notes: Deterministic time trends assume break points at business-cycle peaks (excluding the peaks in 1981 and 2001).

The Hodrick-Prescott filter uses a smoothing parameter of 1,600.

Second, the filters require analysts to make judgments about the values of parameters without providing guidance about satisfactory values. The Hodrick-Prescott filter, for example, requires users to choose a smoothing parameter, which entirely determines how much variation the final estimate will display.

Third, those methods suffer from what is commonly known as the end-of-sample problem. They typically compute the trend value for a certain date using data from both before and after that date—that is, they "average" both past and future values to calculate the trend. Hence, those methods have trouble identifying the trend at the end of the sample (during recent history) because fewer and fewer future values are available to include in the average. Of course, recent history is the period that policymakers are often most interested in because of its bearing on the future.

With respect to the econometric and time-series models, the main disadvantage is that they are highly aggregated and can obscure some underlying relationships in the economy. In a sense, that disadvantage is a mirror image of the key advantage of CBO's method, which allows the sources of growth to be accounted for transparently. The econometric models are largely black boxes—they may indicate, for example, that the growth of potential output has accelerated, but they give no insight into why.