How Useful is Okun's Law?

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From the beginning of 2003 through the first quarter of 2006, real gross domestic product in the United States grew at an average annual rate of 3.4 percent. As expected, unemployment during the period fell. Over the course of the next year, average growth slowed to less than half its earlier rate—but unemployment continued to drift downward. This situation presented a puzzle for policymakers and economists, who expected the unemployment rate to increase as the economy slowed.

Typically, growth slowdowns coincide with rising unemployment. This negative correlation between GDP growth and unemployment has been named "Okun's law," after the economist Arthur Okun who first documented it in the early 1960s. Part of the enduring appeal of Okun's law is its simplicity, since it involves two important macroeconomic variables. Additionally, the relationship appears to enjoy empirical support. In reality, though, Okun's law is a statistical relationship rather than a structural feature of the economy. As with any statistical relationship, it may be subject to revisions in an ever-changing macro economy.

This article considers the usefulness of Okun's law for policymakers and economists. It focuses on two questions. First, is Okun's law a reliable, stable relationship? Second, is the law a useful forecasting tool?

The evidence suggests that Okun's relationship between changes in the unemployment rate and output growth has varied considerably over time and over the business cycle. Nevertheless, Okun's relationship can still be useful as a forecasting tool—provided that one takes its instability into account.

The first section of this article examines the relationships first proposed by Okun. It also reviews the different versions of these relationships, which collectively are called Okun's law. The second section shows how the relationship between changes in unemployment and output growth has varied over time. The third section suggests two explanations for this variation. The fourth section considers how several different versions of Okun's law perform as forecasting tools.

I. WHAT IS OKUN'S LAW?

In his 1962 article, Okun presented two empirical relationships connecting the rate of unemployment to real output, which have become associated with his name.[1] Both were simple equations that have been used as rules of thumb since that time. In addition, both have been expanded on by economists to include elements that Okun omitted in his analysis. This section begins by describing the relationships that are commonly known as Okun's law. Okun's original estimates are then compared with estimates using a longer history of data.

Alternative versions of Okun's law

Okun's two relationships arise from the observation that more labor is typically required to produce more goods and services within an economy. More labor can come through a variety of forms, such as having employees work longer hours or hiring more workers. To simplify the analysis, Okun assumed that the unemployment rate can serve as a useful summary of the amount of labor being used in the economy.

The difference version. Okun's first relationship captured how changes in the unemployment rate from one quarter to the next moved with quarterly growth in real output. It took the form:

Change in the unemployment rate = a + b* (Real output growth).

This relationship can be called the *difference version* of Okun's law. It captures the contemporaneous correlation between output growth and movements in unemployment—that is, how output growth varies simultaneously with changes in the unemployment rate. The parameter *b* is often called "Okun's coefficient." One would expect Okun's coefficient to be negative, so that rapid output growth is associated with a falling unemployment rate, and slow or negative output growth is associated with a rising unemployment rate. The ratio "−*a/b*" gives the rate of output growth consistent with a stable unemployment rate, or how quickly the economy would typically need to grow to maintain a given level of unemployment.

Using quarterly data from the second quarter of 1948 through the fourth quarter of 1960, which would have been available when Okun was writing his original article, one can estimate the above equation and find the following:

Change in the unemployment rate = 0.30 – 0.07* (Real output growth).

This is an example of a regression estimated using "real-time" data, or the data that had been available to economists at a point in the past. Real-time data are useful because they do not reflect the many revisions that macroeconomic statistics typically undergo.[2]

According to this estimate, zero real output growth in a given quarter was associated with an increase in the unemployment rate of 0.3 percentage point in that quarter. The rate of output growth consistent with a stable unemployment rate was a little more than 4 percent. Output growth faster than this rate typically coincided with a falling unemployment rate; slower growth typically coincided with a rising unemployment rate. The value of Okun's coefficient implied that each percentage point of real output growth above 4 percent was associated with a fall in the unemployment rate of 0.07 percentage point.

The gap version. While Okun's first relationship relied on readily accessible macroeconomic statistics, his second relationship connected the level of unemployment to the gap between potential output and actual output. In potential output, Okun sought to identify how much

the economy would produce "under conditions of full employment" (page 98).[3] In full employment, Okun considered what he believed to be an unemployment level low enough to produce as much as possible without generating too much inflationary pressure.

A high rate of unemployment, Okun reasoned, would typically be associated with idle resources. In such a circumstance, one would expect the actual rate of output to be below its potential. A very low rate of unemployment would be associated with the reverse scenario. Thus Okun's second relationship, or the gap version of Okun's law, took the form:

Unemployment rate = c + d*(Gap between potential output and actual output).

The variable *c* can be interpreted as the unemployment rate associated with full employment. The coefficient *d* would be positive to conform to the intuition above.

The problem with both potential output and full employment is that neither is a directly observable macroeconomic statistic. As such, they allow for considerable interpretation on the part of the researcher. For instance, at the time of his writing Okun assumed that full employment occurred when unemployment was 4 percent. Based on this assumption and the gap equation, Okun was able to construct a series for potential output. But changing the assumption of what level of unemployment constituted full employment would produce a different measure of potential output.[4]

Aside from this issue, Okun noted that the simplicity of these equations could potentially be problematic. This has led economists to propose a number of variations on Okun's original relationships. These relationships are also often called Okun's law even though they differ substantially from the earlier equations.

The dynamic version. One of Okun's observations suggested that both past and current output can impact the current level of unemployment (page 102). In the difference version of Okun's law, this implies that some relevant variables have been omitted from the right side of the equation. Partly based on this suggestion, many economists now use a *dynamic version* of Okun's law.

A common form for the dynamic version of Okun's law would have current real output growth, past real output growth, and past changes in the unemployment rate as variables on the right side of the equation.[5] These variables would then explain the current change in the unemployment rate on the left side.[6] This dynamic version of Okun's law bears some similarities to the original difference version of Okun's law. However, it is fundamentally distinct since it no longer only captures the contemporaneous correlation between changes in the unemployment rate and real output growth. The dynamic relationship is not as restrictive in terms of the timing of the connection between output growth and changes in unemployment. But the drawback is that this relationship does not have the same simple interpretation as the original difference version of Okun's law.

Production-function versions. Okun also noted another shortcoming in his proposed relationships: The unemployment rate is at best "a proxy variable for all the ways in which output is affected by idle resources" (page 99). Idle resources can come from a number of sources. Economic theory suggests that a country's production of goods and services requires a combination of labor, capital, and technology. The unemployment rate is but one factor in determining the total amount of labor used as an input; other factors include the population, the fraction of the population that is in the labor force, and the number of hours that employed workers are used.[7] By accounting for all of these components along with the components of capital and technology, economists have a more complete picture of what affects output.

This approach has led to *production-function versions* of Okun's law, which typically combine a theoretical production function—or a particular way in which labor, capital, and technology combine to produce output—with the gap-based version of Okun's law. Doing so allows economists to assess all of the economy's idle resources. Production-function versions of Okun's law have the benefit of an underlying theoretical structure. This contrasts with the previous equations, which were primarily empirically motivated. But there are also drawbacks to this approach, since measuring inputs such as capital and technology is a difficult and imprecise task.[8]

Thus, this article focuses on the difference version of Okun's law and the dynamic version of Okun's law described above. These versions of Okun's law avoid requiring strong—and sometimes controversial—assumptions regarding the definition and computation of potential output and full employment.[9] Additional discussion of the gap version of Okun's law is contained in the appendix.

Updating Okun's law

For comparison with Okun's original estimates, this section updates Okun's law using all of the data currently available since World War II. It finds a negative correlation between quarterly changes in the unemployment rate and real output growth, which is quantitatively quite similar to Okun's original estimates. However, annual data are also used to illustrate the conundrum presented in the introduction, which suggests that Okun's law may not be as stable or as reliable as these estimates initially suggest.

Chart 1 is a scatter plot of the quarterly data for the period between the second quarter of 1948 and the second quarter of 2007. Real output growth on the horizontal axis is measured as the quarterly percentage change in real GDP. Changes in the unemployment rate are the difference between average rates for the three months in each quarter.[10]

The black regression line shows the estimated difference version of Okun's law:

*Change in the unemployment rate = 0.23–0.07 * (Real output growth).*
This regression for the entire postwar era is very close to Okun's original estimates, particularly for Okun's coefficient on real output growth. For this reason, it is easy to see why many economists refer to Okun's relationship as a "law." The only minor difference of note lies in the estimated constant term. Since the (negative of the) constant term divided by Okun's coefficient gives the rate of output growth consistent with a stable unemployment rate, this implies that the economy required slightly more rapid growth to maintain a given level of unemployment in Okun's time than it has over a longer time span.

The same exercise can be done with the dynamic version of Okun's law. Table 1 presents results from a dynamic version of Okun's law. The same equation was estimated twice. The first estimation was made using

Chart 1

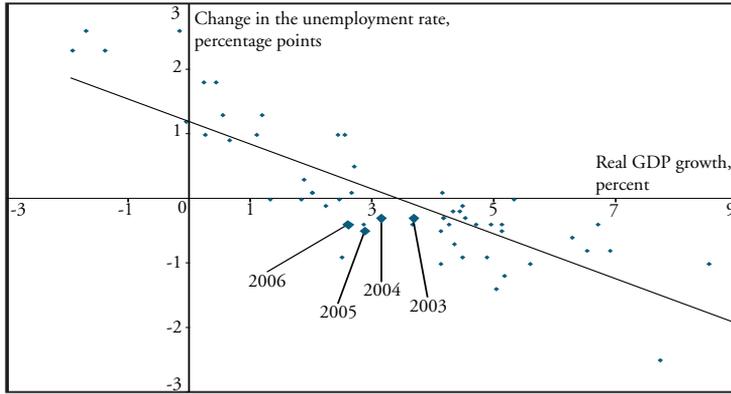## THE DIFFERENCE VERSION OF OKUN'S LAW, QUARTERLY DATA
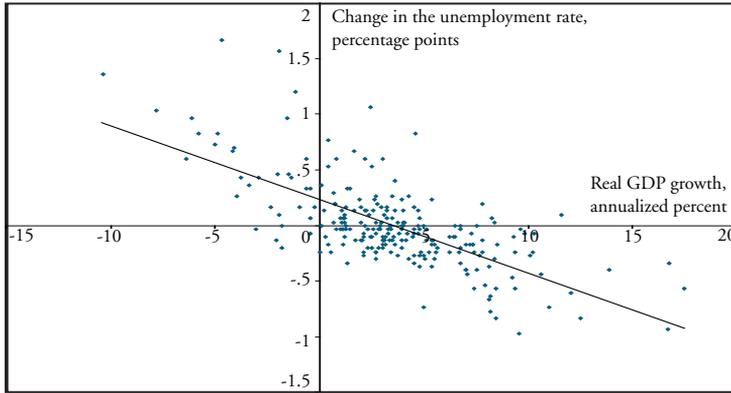
Note: Data are from the Bureau of Economic Analysis and Bureau of Labor Statistics, from the second quarter of 1948 through the second quarter of 2007.

Table 1

THE DYNAMIC VERSION OF OKUN'S LAW, QUARTERLY DATA

Left hand side variable:	Current change in unemployment	
Right hand side variable:	**1948-60**	**1948-2007**
Constant	.38	.28
Current real output growth	-.05	-.05
Real output growth, one quarter in the past	-.02	-.02
Real output growth, two quarters in the past	-.02	-.01
Change in unemployment, one quarter in the past	.30	.31
Change in unemployment, two quarters in the past	-.26	-.12

Chart 2

THE DIFFERENCE VERSION OF OKUN'S LAW, ANNUAL DATA

Note: Data are from the Bureau of Economic Analysis and Bureau of Labor Statistics, from 1949 through 2006.

the data from 1948 through 1960 that were available at the time of Okun's research. The second estimation was done using the entire sample of data since 1948.[11] The table delivers a message similar to the previous result: the coefficients of a dynamic version of Okun's law are similar whether one looks over a very long period (1948-2007) or a short one (1948-60).

Given these findings, why did the recent slowdown in growth not coincide with a rise in the unemployment rate as Okun's law would predict? One explanation is that there are simply many transitory exceptions to the "law." The scatter plot in Chart 1 shows that the correlation between changes in the unemployment rate and real output growth has not been very tight at all points in time. This can be seen by the fact that many data points are far away from the regression line.

A second possible explanation is that the law has not always been as stable as these estimates suggest. To help illustrate this point, Chart 2 shows a scatter plot of the annual data for real output growth and the change in unemployment from 1949 to 2006.[12] The black line in the figure is the estimated regression equation with annual data:

Change in the unemployment rate = 1.20 – 0.35 [*] *(Real output growth).*

If one were to divide the coefficients by four, the result would be roughly similar to what had been obtained earlier with the quarterly data. The interesting feature of Chart 2 is that the annual data points for 2003 through 2006—the period mentioned in the introduction as posing a conundrum for Okun's law—all lie well below the estimated regression line.[13] Over these years, the correlation between changes in unemployment and real GDP growth was virtually zero. This contrasts with the regression results presented above, which suggested a strong negative correlation between these variables. This raises the question: Has Okun's law been stable over time?

II. HAS OKUN'S LAW BEEN STABLE OVER TIME?

One problem with a long time series—such as from 1948 to 2007—is that history can hide changes in relationships. This is the case for Okun's law. The previous section found considerable similarities between Okun's original estimates and an updated regression using a longer time series. This section shows that, when estimated over shorter time horizons, the relationship between changes in the unemployment rate and real output growth has varied considerably.

To capture this variation, this article uses a technique called rolling regressions. A rolling regression estimates a particular relationship over many different sample periods. Each regression produces a set of estimated coefficients. If the relationship is stable over time, then the estimated coefficients should be relatively similar from one regression to the next. Variations in the relationship will appear as sizable movements in the estimated coefficients.

Each rolling regression is estimated based on 52 quarterly data points. This sample length was based on the original results for the difference version of Okun's law, which used 13 years of data.[14] Thus, the first rolling regression would estimate the values of a and b from the difference version of Okun's law, using the sample period from the second quarter of 1948 to the first quarter of 1961. The sample period is then moved forward one quarter in time, and the regression is re-estimated to produce a second set of estimates of a and b, using data from the third quarter of 1948 through the second quarter of 1961. This process is repeated until the final estimates are made using the sample period from

Chart 3
ROLLING REGRESSION ESTIMATES

Notes: Dates along the horizontal axis denote the last quarter in the sample period for each rolling regression. Each sample period is 13 years long.

the third quarter of 1994 through the second quarter of 2007. This method ensures that the distant past (for example, the 1950s) does not affect the estimation of the recent relationship (for example, the 1990s and 2000s).[15]

Real-time data series are also employed in the rolling regressions, for several reasons.[16] First among these is to put into historical perspective the experience of the last few years—using data that are currently available in real time. Comparing the current real-time data with the real-time data from points in the past can help assess whether the recent period has been truly unique. Second, policymakers may use Okun's law as a real-time rule of thumb to assess conditions in the labor markets and the product market, and forecasters may use Okun's law as a real-time forecasting tool. Thus, it can be useful to compare the relationships that economists would have estimated at points in the past with those estimated today.[17]

Chart 3 presents the rolling regression parameter estimates for the difference version of Okun's law. Each set of estimated parameters is plotted based on the last quarter of data used in the rolling regression (horizontal axis). In addition to Okun's coefficient, the rate of output

growth consistent with a stable unemployment rate over a certain time period is also plotted, using the estimated coefficients. Several features can be seen from this chart.

First, while Okun's coefficient has consistently been negative, it has varied considerably over time.[18] Starting at –0.068 in the first rolling regression, Okun's coefficient experienced moderate fluctuations around this level, in particular during the early 1970s, until the mid-1990s. (Recall that over the entire time period, Okun's coefficient was estimated to be –0.066.) For the rolling regressions whose sample periods ended around 1997, however, Okun's coefficient suddenly increased. Unlike the other increases in this measure, which occurred earlier, estimates of Okun's coefficient persisted at their new, higher level through the remainder of the rolling regressions, ending at –0.040 in the last rolling regression.[19]

Quantitatively, the changes in the parameters of Okun's law have important implications for using the law as a simple rule of thumb. For instance, from 2003 to 2007, real GDP growth averaged about 3 percent per quarter at an annualized rate. Given this rate of GDP growth, Okun's law based on the entire sample would have predicted increases in the unemployment rate. However, if one were to use the last set of coefficients from the rolling regressions, this average growth rate would have pointed toward *decreases* in the unemployment rate.[20]

The rate of output growth consistent with stable unemployment is the (negative of the) ratio of the estimated constant term to Okun's coefficient. This measure was higher and more stable in the first half of the sample than in the second half. Thus, faster economic growth was required in the first half of the sample to maintain a given level of the unemployment rate than it was later in the sample.

While many factors could affect this ratio—including the estimation of Okun's coefficient itself—one possible factor is demographic trends. The unemployment rate followed a distinct upward trend during the late 1960s and throughout the 1970s, followed by a distinct downward trend from the beginning of the 1980s through the end of the sample. This timing coincides with the impact of the baby boom generation on the labor market. Younger workers typically have higher unemployment rates than older workers. As the large baby boom gener-

ation began to enter the labor force in the 1970s, this helped push up the unemployment rate. Later, the maturation of this cohort of workers had the exact opposite effect on the unemployment rate.

Is there a similar, simple explanation for the change in Okun's coefficient in the latter part of the data? In particular, it is worth noting that a large change in the estimate of Okun's coefficient in Chart 3 occurred around 1997. Since the horizontal axis lists the last quarter of each sample period, and each sample period consists of 13 years of data, this means that substantial changes in Okun's coefficient occurred when using data from 1984 to the present. The timing of this phenomenon is intriguing because 1984 has been identified as an important year in macroeconomics for another reason: It is the start of what economists have called the Great Moderation.[21] The term Great Moderation comes from the fact that U.S. economic activity suddenly and dramatically became less volatile in 1984, a trend which has persisted to this day. The next section investigates whether there is a connection between these events in an attempt to determine why Okun's coefficient has changed over time.

III. WHAT CAN EXPLAIN CHANGES IN OKUN'S LAW?

What can explain changes in Okun's law? The timing of a substantive change in Okun's law, indicated by a change in Okun's coefficient, and the onset of the Great Moderation suggest a connection between the two events. However, this is not the only interpretation of the data. This section outlines two possible explanations for why Okun's law has varied over time. First, it documents that Okun's law has been sensitive to the state of the business cycle. Because the economic expansions that have occurred since the onset of the Great Moderation have been longer than average by historical comparison, this has helped to drive some of the observed changes in Okun's coefficient toward the end of the sample. Second, there have also been recent changes in the dynamics of the relationship between output and unemployment.

Chart 4

OKUN'S COEFFICIENT IN EXPANSIONS
AND RECESSIONS
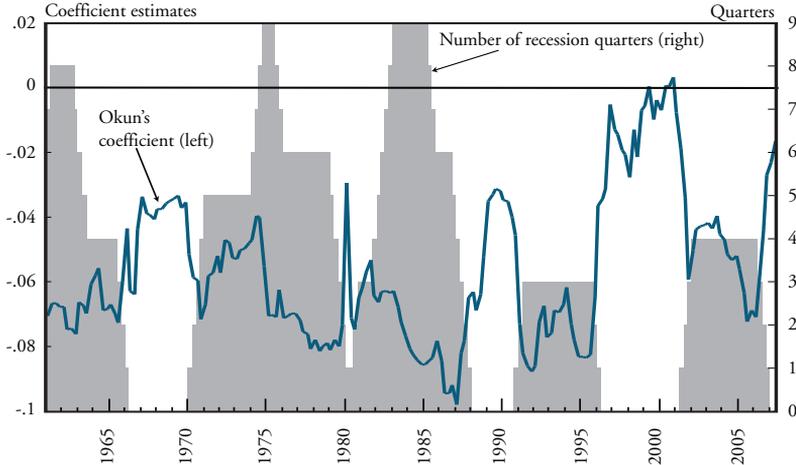
Notes: Dates along the horizontal axis denote the last quarter in the sample period for each rolling regression. Each sample period is five years long. Bars denote the number of quarters within a given sample period that are classified as recessions.

Okun's law and the business cycle

Since World War II, no economic expansion in the United States has lasted more than ten years. Thus, in the rolling regressions of the previous section, each 13-year sample period is guaranteed to contain data from at least one recession. It turns out that this is an important consideration when examining the difference version of Okun's law.

To isolate the effect that the business cycle may have on the relationship between output growth and changes in the unemployment rate, the line in Chart 4 plots Okun's coefficient for a new set of rolling regressions based on only five years of data. Thus, it allows for different treatment of periods such as 1995–2000, which did not experience a recession, and 2000-05, which included one recession. A sample of 20 quarters for each regression is very short in econometric terms. However, using a short sample allows for many opportunities to compare estimates of Okun's law during periods only characterized by

expansion with estimates for periods that experienced a recession. In addition, the short samples assist in assessing the usefulness of Okun's law as a short-term rule-of-thumb relationship.

For each rolling regression, the vertical gray bar associated with it is the number of quarters in that five-year sample that were classified as a recession by the National Bureau of Economic Research (NBER).[22] For instance, the 2001 recession began in March (the first quarter) and ended in November (the fourth quarter). The rolling regression covering the period from the third quarter of 2000 through the second quarter of 2005 contained all four of these quarters. By contrast, the five-year period ending with the second quarter of 2007 included zero quarters of recession.

The chart shows a strong negative correlation between Okun's coefficient and the number of recession quarters. The five-year periods that were entirely classified as expansions—the late 1960s, late 1980s, late 1990s, and the 2000s at the end of the sample—were associated with Okun's coefficients smaller in absolute value, on average, than the coefficients derived from periods around recessions.[23] Thus, the figure offers strong evidence that Okun's law varies considerably over the business cycle.

To follow up with the suggestion from the previous section, the onset of the Great Moderation does not appear to play a key role in driving changes in Okun's coefficient. The beginning of the Great Moderation in 1984 should begin to affect the estimates around the year 1989 because of the five-year sample periods. While Okun's coefficient decreases in absolute value around this time, this change is not extraordinary compared with other sample periods. Instead, it appears to simply be associated with the end of the severe 1981-82 recession.[24]

In addition, the figure also shows that the negative correlation between the change in the unemployment rate and real output growth has *not* always been so reliably negative over short time spans. During the late 1990s and again at the end of the sample (2006 and 2007), the contemporaneous correlation between changes in unemployment and output growth is close to zero. These estimates suggest that the simple difference version of Okun's law may not be able to provide much information about divergent trends in labor markets and output during times of general economic expansion.

It is important to note that the NBER recession data do not reflect real-time data, since the announcement dates for all business cycle peaks (the beginnings of recessions) and troughs (the ends of recessions) are not available. In addition, NBER announcements tend to considerably lag the dates of peaks and troughs. For instance, the NBER classifies the 2001 recession as beginning in March and ending in November of that year. However, the formal announcement of the recession's onset came on November 26, 2001; the announcement of the recession's end came on July 17, 2003. For these reasons, it is not logically consistent to explicitly include recession data in a regression using real-time data.

### Okun's law and the dynamics of unemployment and output

Changes in the economy's dynamic relationships offer a second means of examining why the contemporaneous correlation between movements in unemployment and output growth has varied over time. In particular, the U.S. economy in the aftermath of the 1990-91 and 2001 recessions experienced a new phenomenon: "jobless recoveries." Jobless recoveries are periods following the end of recessions when output growth resumes but employment does not grow.[25] It is possible that the advent of jobless recoveries is symptomatic of a fundamental change in the timing of the relationship between output and the labor market that the simple difference version of Okun's law is not able to capture.

This section examines such a scenario by focusing on the dynamic version of Okun's law set out in Section I. This section estimates rolling regressions under the assumption that current changes in the unemployment rate are affected by current output growth, past output growth, and past changes in the unemployment rate. Each rolling regression uses a sample period consisting of 13 years of data.

Chart 5 displays the estimated coefficients on current output growth and past output growth for several of the rolling regressions.[26] The dates along the horizontal axis denote the last quarterly data point included in each regression. The sample period for the first rolling regression consists of data from the second quarter of 1948 through the first quarter of 1961. This is the first set of columns on the left side. The last rolling regression uses the sample period from the third quarter of 1994 through the second quarter of 2007. The estimated coefficients on output growth

Chart 5

THE CHANGING DYNAMICS OF UNEMPLOYMENT AND OUTPUT
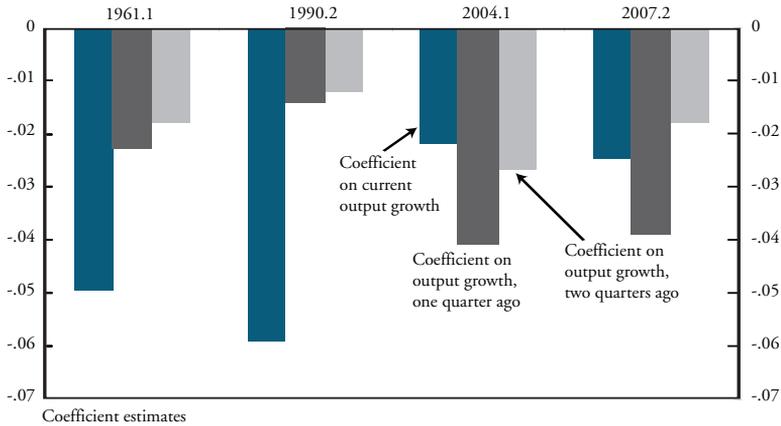
Notes: Dates along the horizontal axis denote the last quarter in the sample period for each rolling regression. Each sample period is 13 years long.

and its past values from this rolling regression are the final set of columns on the right side. These sets of columns show that the dynamic version of Okun's law has not been perfectly stable over time.

   The chart also shows two other sets of estimates that illustrate the changes that have occurred in the dynamic version of Okun's law since the first jobless recovery associated with the 1990-91 recession. The first of these uses the sample period ending immediately prior to the recession, in the second quarter of 1990. The other set of estimates are based on the sample period for the 13 years of data immediately following the recession, from the second quarter of 1991 through the first quarter of 2004. In fact, the latter sample covers two jobless recoveries, the 2001 recession, and the economic boom of the 1990s.

   The chart reveals another reason why the contemporaneous correlation between changes in unemployment and output growth has become weaker over time: The dynamic relationship between these variables has changed. Mathematically, for each group of three coefficients, the estimate which is greatest in absolute value in the chart determines when output growth has its maximum effect on unemployment.[27] For both sets of estimates prior to the 1990-91 recession, the chart shows that contemporaneous output growth typically had the largest impact on the

unemployment rate, since these were the largest negative coefficients. For this reason, the simple difference version of Okun's law—which only involves contemporaneous values for the change in unemployment and output growth—was able to capture much of the relationship between growth and unemployment.

The two sets of coefficients on the right side of the chart show how the pattern has changed since the 1990-91 recession. For both regressions, the largest negative coefficients are associated with output growth one quarter in the past. This implies that changes in the unemployment rate in a given period now depend more on previous values of output growth than on the contemporaneous value of output growth.

This finding is in line with what one should expect during jobless recoveries in which output growth rebounds before employment. Yet jobless recoveries are only part of the recent picture. In addition, it now appears that the dynamics of the relationship between economic growth and unemployment have changed over the entire duration of the business cycle.[28]

Taken together, this section has shown that the simple difference version of Okun's law is affected by the business cycle and by variation in the timing of the connection between growth and unemployment. Furthermore, the latter suggests a reason to generally prefer the dynamic version of Okun's law. The next section builds on the previous results and assesses the performance of Okun's law in a typical application: economic forecasting.

IV. FORECASTING AND OKUN'S LAW

The previous sections showed that Okun's law has not been useful as a stable relationship, since its parameters have varied considerably over time and over the course of the business cycle. In addition, it has not always been a reliably strong relationship, especially in quarterly data. Nevertheless, the relationship between contemporaneous changes in unemployment and output growth may still be useful to policymakers and economists if they take these shortcomings into consideration. This section examines one such possibility by assessing Okun's law as a forecasting tool. It compares alternative forms of Okun's law with a common baseline forecasting model. The results show that incorporating instability is important in producing more accurate unemployment

forecasts. While Okun's simple difference relationship can improve on the baseline forecasting model, on average the dynamic version of Okun's relationship produces the most accurate forecasts.[29]

One popular and relatively successful method of forecasting is to use the recent history of a macroeconomic variable to forecast its own future values. This is an example of an autoregressive model—a variable regressed on its own past values. In this case, for the sake of comparison with Okun's law, one could use an autoregressive model to posit that the change in the unemployment rate at a point in time is a function of the changes in the unemployment rate in the two quarters immediately preceding it.[30] To determine the parameters of the model, one could estimate this relationship over a time span in the recent past. Then, one could make a forecast of the change in the unemployment rate one quarter into the future based on those parameters and the two most recent data points. In turn, one could use the parameters, the one-quarter forecast, and the most recent data point to make a forecast for two quarters into the future. This procedure can be repeated as necessary to forecast arbitrarily far into the future.

This autoregressive model for forecasting the change in the unemployment rate forms the basis for comparison in this section. In each quarter, recent data are used to estimate the parameters of the autoregressive model.[31] Following the procedures set out above, forecasts are constructed for the next four quarters. Forecast errors are then computed. These forecast errors are the difference between the forecasted and the actual levels of unemployment that occurred in the data, with absolute values used to ensure that all errors are treated equally.[32]

This baseline forecasting model is compared with forecasts from three alternative forms of Okun's law: 1) The first set of forecasts is generated based on Okun's original relationship, the difference version of Okun's law. At each point in time, this relationship is estimated based on all the available data, and then forecasts are made based on that relationship.[33] 2) The second set of forecasts also uses the difference version of Okun's law. However, it allows the parameters in the relationship to vary based on the rolling regression results from Section II. 3) The third set of forecasts uses the dynamic version of Okun's law and allows the

Chart 6

AVERAGE FORECAST ERRORS COMPARED WITH THE BASELINE MODEL, 1984-2006
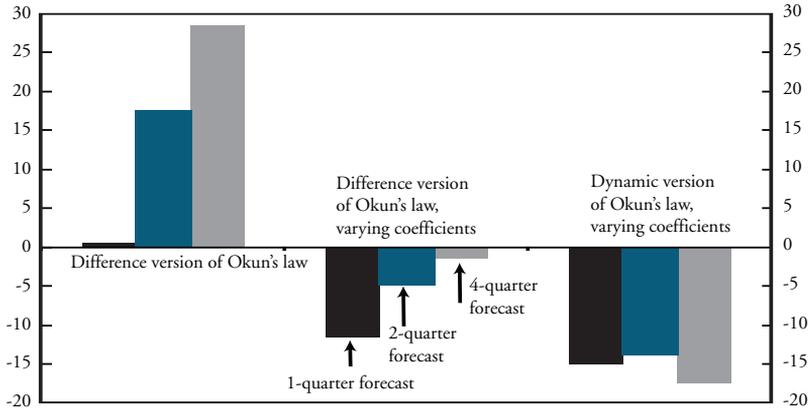
Notes: Bars indicate the percentage difference between the average absolute forecast errors from the listed version of Okun's law and the average absolute forecast errors from the baseline autoregressive model. Positive bars indicate errors (in absolute terms) are larger than the baseline model. Negative bars indicate errors (in absolute terms) are smaller than the baseline model.

coefficients in this relationship to vary over time. While lacking the simplicity of the other two forms, this relationship is not as restrictive in the timing between output growth and changes in the unemployment rate.[34]

To make these forecasts with Okun's law, one must also have forecasts of output growth in the future. In the contemporaneous relationship, for instance, the one-quarter forecast for the change in the unemployment rate would depend on a one-quarter forecast for output growth.[35] For output-growth forecasts, this paper uses the average forecasts provided by the Survey of Professional Forecasters. Clark and McCracken (2006) show that these forecasts are often superior to a variety of other forecasting methods over short time horizons. Real-time forecasts from this survey are available beginning in the fourth quarter of 1968.[36]

To assess how well a particular model is able to forecast, one can compare the difference between the average forecast errors produced by that model and the average forecast errors produced by the baseline model. Moreover, one can make this comparison for different forecast horizons.

Chart 6 shows how the three forms of Okun's law perform compared with the baseline autoregressive model. The comparison is made using the recent data from 1984 to 2006, and forecasting performance over one-, two-, and four-quarter horizons. The chart displays the percentage difference between the average errors from forecasting with a particular form of Okun's law and the average errors from the baseline forecasting model. For a given horizon and a given form, a positive bar indicates that the particular form of Okun's law generates larger forecast errors, on average, than the baseline model. A negative bar indicates that the form of the model produces smaller forecast errors over that time horizon than the baseline model.

The chart shows that since the beginning of the Great Moderation in 1984, the difference version of Okun's law estimated using all the available data generates larger forecast errors than the baseline autoregressive model. This is especially true at longer forecast horizons. For a forecast one year into the future, the autoregressive model's average errors are nearly 30 percent smaller than those from Okun's law.

However, the chart also demonstrates that taking the instability of Okun's law into account improves forecasting of the unemployment rate. For making a forecast one quarter into the future, the difference version of Okun's law whose coefficients vary over time does almost as well as the dynamic version. At longer forecast horizons, the dynamic version of Okun's law with varying coefficients produces the most accurate forecasts of the models considered.[37] Nevertheless, both of these forecasting methods produce smaller forecasting errors—on average— than the baseline autoregressive model. These results suggest that Okun's law can be a useful tool for forecasting changes in unemployment.

V. CONCLUSION

As a relationship between changes in the unemployment rate and economic growth, Okun's law predicts that growth slowdowns typically coincide with rising unemployment. The recent experience of 2006 shows, however, that this is not always the case. This article has documented several reasons for this.

First among these is that Okun's law is not a tight relationship. There have been many exceptions to Okun's law, or instances where growth slowdowns have not coincided with rising unemployment. This is true when looking over both long and short time periods. This is a reminder that Okun's law—contrary to connotations of the word "law"—is only a rule of thumb, not a structural feature of the economy.

This article has also documented that Okun's law has not been a stable relationship over time. Part of this variation is related to the state of the business cycle: The relationship between output and unemployment is different in recessions and expansions, and recent expansions have been longer than average. Additionally, the data suggest that a weakening of the contemporaneous relationship between output and unemployment has coincided with a stronger relationship between past output growth and current unemployment. This finding favors versions of Okun's law that are less restrictive in the timing of this dynamic relationship.

These findings have practical applications. For instance, forecasting the unemployment rate via Okun's law is much improved by taking into account its changing nature. These forecasts can be improved even more by allowing for a dynamic relationship between unemployment and output growth.

APPENDIX

STABILITY AND THE GAP VERSION OF OKUN'S LAW

The main focus of this paper has been the difference version of Okun's law. This focus avoids complications that arise when one must make assumptions regarding the unobserved macroeconomic variables necessary to work with the gap version of Okun's law. This appendix briefly provides more details on the gap version of Okun's law and provides an analysis of its stability for one particular set of assumptions.

Okun's original paper was motivated by identifying a way to measure potential output. In potential output, Okun sought the answer to the question, "How much output can the economy produce under conditions of full employment?" (page 98). Unlike many macroeconomic variables, neither potential output nor the level of unemployment that constitutes "full employment" is a directly observable concept.

Nevertheless, Okun showed how one could make several assumptions to generate such a series. The first of these was to assume that there was a full-employment level of unemployment—hereafter labeled U^F for the sake of exposition—and that this level was 4 percent.[38] The second assumption Okun made was that there was a relationship between unemployment and the output gap, which took the form:

Unemployment rate = c + d*(Gap between potential output and actual output).

Finally, Okun assumed that one could use trial and error to construct a series for potential output based on the premise that potential output should equal actual output when the unemployment rate equals U^F.

The problem with Okun's exposition of this approach is its circular logic. Since the output gap is unobservable, Okun assessed the validity of possible potential output values by checking that potential output equaled actual output when the unemployment rate was equal to U^F. But this effectively implies that the variable c in the above equation is equal to U^F. As a consequence, Okun essentially used the same equation twice: First he used it to select a good measure for potential output; then he used this measure for potential output to estimate the parameters of the equation.

When working with the gap version of Okun's law, economists in the literature often try to avoid this issue by rewriting Okun's proposed relationship, subtracting the full-employment level of unemployment from both sides, so that one has the following:

*Unemployment gap = d * (Gap between potential output and actual output).*

Thus, if output is below its potential level, the unemployment rate will tend to be greater than the level needed for full employment.[39] Moreover, if *d* is constant, then the two gaps are approximately proportional across time.

To estimate *d* using this specification, one needs measures for the unemployment gap and the gap between potential and actual output. This article derives these gaps separately and estimates this gap version of Okun's law.[40] A common statistical procedure that captures trends in macroeconomic data—the Hodrick-Prescott (HP) filter—is applied to the unemployment rate and the actual output rate individually. The results are then used to generate series for the unemployment gap and the gap between potential and actual output. To assess the stability of this relationship, 13-year moving windows are used with the real-time data.[41]

Chart A shows that the coefficient in this gap version of Okun's law has varied considerably over time. Depending on the time period, output that was 1 percent below potential has been associated with unemployment anywhere from 0.3 to 0.75 percentage point above its full-employment rate. The most recent data suggest that we should expect unemployment 0.5 percentage point above the full-employment rate for a 1 percent shortfall of output from potential. Thus, rolling regressions using the HP filter to derive trends in the unemployment and output series do not find stability in the gap version of Okun's law.

Chart A

ROLLING REGRESSIONS AND THE GAP VERSION OF OKUN'S LAW
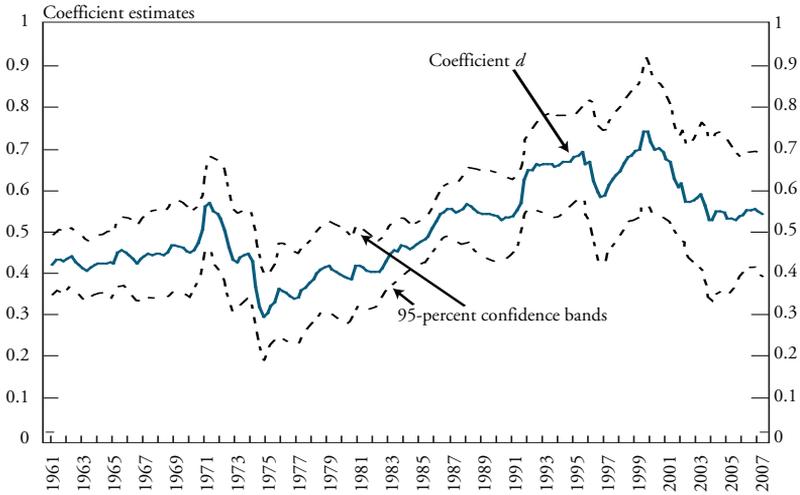
Coefficient estimates

Coefficient d

95-percent confidence bands

Notes: Dates along the horizontal axis denote the last quarter in the sample period for each rolling regression. Each sample period is 13 years long.

ENDNOTES

[1]Okun actually discussed three relationships, but the third relationship is observationally equivalent to one of the others and hence is not discussed. The literature on Okun's law is extensive; the references listed in this paper provide merely a starting point for additional resources for the topics covered. Some of the contributions of this paper include the use of real-time data, including data through 2007; rolling regression estimates using quarterly data of difference versions of Okun's law; and their implications for forecasting.

[2]This paper uses the real-time data sets available through the Federal Reserve Bank of St. Louis and the Federal Reserve Bank of Philadelphia for unemployment and real output, where real output was gross national product (GNP) prior to 1992 and gross domestic product (GDP) thereafter. The regression in the text was run using data known as of the fourth quarter of 1961. This date coincided with the timing of the release of Okun's regressions and produced the best match with Okun's reported estimates. Varying the choice of the real-time date does not materially affect the estimates.

While Okun's regression included data from the second quarter of 1947 through the fourth quarter of 1960, neither real-time data repository has the unemployment rate during 1947. However, the omission of 1947 does not appear to be serious. Okun's reported regression results were $\Delta U_t = 0.30 - 0.30^* g_t$, where ΔU_t is the change in the unemployment rate and g_t is real output growth. The major difference compared with the regression result in the text is that Okun did not use annualized rates of output growth. Re-estimating the regression in the text without annualizing output growth produces $\Delta U_t = 0.30 - 0.29^* g_t$

[3]It is worth noting that Okun's original paper was motivated by identifying a way to measure potential output; hence the title, "Potential GNP: Its Measurement and Significance." The gap version of Okun's law is still used as a means of generating estimates of potential output by some economists. The appendix discusses this in more detail.

[4]A common alternative way of writing the gap version of Okun's law is to subtract c, the unemployment rate associated with full employment, from both sides. This results in the unemployment gap on the left side and the output gap on the right side. The parameter d is the factor of proportionality between the two gaps.

[5]Another reason for including past changes in the unemployment rate as variables on the right side of the dynamic version of Okun's law is to eliminate serial correlation in the error terms from regressing the difference version of Okun's law.

[6]For instance, one form for the dynamic version of Okun's law contains two lags of real output growth and two lags of the change in the unemployment rate: $\Delta U_t = \beta_0 + \beta_1^* g_t + \beta_2^* g_{t-1} + \beta_3^* g_{t-2} + \beta_4^* \Delta U_{t-1} + \beta_5^* \Delta U_{t-2}$.

[7]For more on this issue, see Gordon (1984) and Altig and others (1997).

[8]Gordon (1984), Prachowny (1993), and Attfield and Silverstone (1997), among others, invert the gap version of Okun's law and combine it with a fully specified production function.

[9]In addition, this article conforms to Okun's original specification and keeps changes in the unemployment rate as a variable on the left side of the regressions and the growth of real output as a variable on the right side of the regressions. This is partly due to the fact that economists and forecasters may have better

models of, and forecasts for, real output than those for unemployment. For instance, forecasters may construct individual predictions of the components of GDP, sum those components to form forecasts of GDP growth, and then use a modification of Okun's law to form a forecast of unemployment.

   In particular, integrated models featuring monetary policy and unemployment are only now beginning to appear; see, for instance, Blanchard and Galí (2006). For the most part, New Keynesian dynamic stochastic general equilibrium models—including medium-scale models of the type developed by Smets and Wouters (2003)—have avoided unemployment per se. Moreover, see Shimer (2005) for evidence on the severe shortcomings of the models that do include unemployment.

   [10]The data are those available as of August 15, 2007. Real gross domestic product is in billions of chained 2000 dollars from the U.S. Department of Commerce's Bureau of Economic Analysis. The quarterly unemployment rate averages over the seasonally adjusted monthly civilian unemployment rates produced by the U.S. Department of Labor's Bureau of Labor Statistics.

   [11]The dynamic version of Okun's law is $\Delta U_t = \beta_0 + \beta_1 * g_t + \beta_2 * g_{t-1} + \beta_3 * g_{t-2} + \beta_4 * \Delta U_{t-1} + \beta_5 * \Delta U_{t-2}$. The choice of lag length was determined by the Akaike criterion for the entire 1948-2007 period. This same form was estimated using the real-time data that would have been available to Okun for 1948-60.

   [12]Real output growth is the Q4/Q4 percentage change in real GDP, and the change in unemployment is the December-over-December change in the unemployment rate. Blanchard (2006) and Rudebusch (2000), among others, employ annual data in Okun's law.

   [13]The vast majority of the quarterly data points for this period do likewise. The annual data show this pattern more clearly.

   [14]Selecting a different length for the moving window, such as 10 or 15 years, has a minimal impact on the results. The next section shows that what matters more for the results is the number of quarters that the economy is in recession within each moving window.

   [15]Besides rolling regressions (Moosa 1997), there are other techniques that could be used to measure time variation in the parameters of Okun's law, such as allowing for one-time breaks (Weber 1995, Lee 2000) or implementing econometric techniques that explicitly allow for time-varying coefficients (Sogner and Stiassny 2002). The rolling regression results are especially useful for forecasting in Section IV.

   [16]Each rolling regression is made using the data that would have been available to economists and policymakers immediately following the end of each moving window. To be precise, the Federal Reserve Bank of Philadelphia's real-time data set consists of data available as of the 15th day of the middle month of each quarter. Thus, for instance, the first moving window comprises observations between the second quarter of 1948 and the first quarter of 1961, based on data known as of May 15, 1961.

   [17]This will be especially true when the issue of forecasting is taken up in Section IV. While the results from performing the same rolling regression exercise using the most recent vintage of data available as of August 15, 2007, were similar to those using real-time data, they do not offer the same advantages as the real-time data.

[18]While not plotted in the figure, the standard errors of the estimated Okun coefficients were around 0.03 in regressions whose data sets ended in the 1960s through the 1980s, and around 0.05 in the 1990s and 2000s. However, there is some evidence of serial correlation in the errors terms for the data sets ending in the mid-to-late 1970s, the late 1990s, and the 2000s.

[19]In addition to this instability in Okun's coefficient, a second point concerns the fit of Okun's law—that is, whether Okun's law provides a tight fit to the data. A common way of assessing goodness-of-fit is to examine the adjusted R-squared measure. Making comparisons via adjusted R-squared is problematic across data samples (see Kennedy 2003). Nonetheless, this measure is remarkably stable around 0.57 from 1961 until 1996, at which point it falls off before ending the sample at 0.17 in the second quarter of 2007. This reinforces the earlier finding that—even with parameters that vary over time—Okun's law has not been a reliably tight relationship.

[20]Mathematically, using the difference version of Okun's law for the whole period and the average 2003–07 growth rate of 2.96 percent produces $\Delta U_t = 0.231 - 0.066^* 2.96 = 0.036$. Using the estimated parameters in the final rolling regression produces $\Delta U_t = 0.093 - 0.041^* 2.96 = -0.028$. Thus, the error would be slightly above six basis points. However, given that the average (absolute) change in the unemployment rate during the period 2003-07 was 12 basis points, the error would have been 50 percent of the average change.

[21]See McConnell and Perez-Quiros (2000). Summers (2005) examines causes of the Great Moderation in a previous issue of the *Economic Review*.

[22]The NBER's Business Cycle Dating Committee serves as an arbiter of recession dates, deciding when recessions begin and when they end. NBER-defined recession dates are available online at *www.nber.org/cycles.html/*.

[23]This result is not too surprising. Recessions are endogenously determined by the National Bureau of Economic Research based on a "significant decline in economic activity" as seen through real GDP (output) and employment (or its complement, unemployment), among other variables; see *www.nber.org/cycles.html/*. Thus, recessions are concentrated periods in which output growth is weak or negative and the unemployment rate rises sharply. Regression results which use these data therefore pick up this strong negative correlation between the change in unemployment and output growth. By contrast, expansions tend to be longer and contain a broader variety of circumstances which may not fit Okun's law as well; for instance, slight timing variations may induce a quarter of very strong output growth following a weak quarterly growth reading, while unemployment drifted down throughout the two quarters.

[24]Using different techniques, Lee (2000), Cuaresma (2003), and Silvapulle and others (2004), investigate asymmetry in Okun's law.

[25]See, for instance, the articles by Schreft and Singh (2003) and Schreft and others (2005) in previous issues of the *Economic Review*.

[26] The dynamic version of Okun's law is $\Delta U_t = \beta_0 + \beta_1^* g_t + \beta_2^* g_{t-1} + \beta_3^* g_{t-2} + \beta_4^* \Delta U_{t-1} + \beta_5^* \Delta U_{t-2}$. The coefficients on lagged changes in unemployment are omitted from the figure for the sake of exposition; however, their omission understates the instability of the relationship, since they also vary considerably over time. While the Akaike criterion for lag length selection could

suggest varying the lag length in each rolling regression, two lags were used for the sake of compatibility across regressions. Similar patterns arise when using a different length for the moving window.

[27]This is a slight simplification, since the coefficients on the lagged change in the unemployment rate also affect the computation. However, the differences among these estimated coefficients are not large enough to affect the analysis in the text.

[28]In previous issues of the *Economic Review*, Schreft and Singh (2003) and Schreft and others (2005) consider several explanations for jobless recoveries, including "just-in-time" employment practices such as greater use of overtime, temporary workers, and part-time workers. These results support the idea that employers have been more apt to first adjust the intensive margin (the number of hours that employees work, such as through increased overtime) before adjusting the extensive margin (the number of employees).

[29]Braun (1990) is one example that uses Okun's law for purposes of forecasting.

[30]For the change in the unemployment rate, an autoregressive process with two lags—an AR(2)—is used: $\Delta U_t = \alpha_0 + \alpha_1 * \Delta U_{t-1} + \alpha_2 * \Delta U_{t-2}$. Alternative lag lengths generate similar results. Montgomery and others (1998) discuss forecasting the U.S. unemployment rate using an autoregressive model.

[31]For comparison with the other forecasting models, the parameters are estimated based on data for the preceding 13 years. Thus the parameters of the baseline forecasting model can vary over time.

[32]An alternative metric of forecast accuracy is root mean-squared error (RMSE). For the period 1984-2006, the RMSE results are similar to those in Chart 6.

[33]This approach is akin to the exercises in Section I, which estimated the relationship as it appeared to Okun and then re-estimated the relationship using all the available data. Those results suggested that Okun's coefficient had not changed dramatically over time, but the constant in the regressions had changed slightly. Thus, this approach is distinct from using the rolling regression results, which documented substantial instability in both parameters.

[34]The dynamic version of Okun's law is $\Delta U_t = \beta_0 + \beta_1 * g_t + \beta_2 * g_{t-1} + \beta_3 * g_{t-2} + \beta_4 * \Delta U_{t-1} + \beta_5 * \Delta U_{t-2}$. As in Section III, the β coefficients are estimated via rolling regressions with 13-year moving windows, thus its coefficients also are allowed to vary over time. For consistency with the autoregressive baseline forecasting model, the generated forecasts of the change in unemployment are subsequently used in the two- through four-step forecasts as explanatory variables.

[35]That is, given the relationship $\Delta U_t = a + b^* g_t$, the forecast of the change in unemployment at time $t+1$ would be $a + b^* (Forecast\ of\ g_{t+1})$.

[36]The Survey of Professional Forecasters (SPF) began asking explicitly for forecasts of real output growth in 1981:Q3. Prior to that time, forecasts for real output growth were inferred based on published forecasts of nominal output growth and inflation. This article uses the mean forecasts from the SPF; the median forecasts generate similar results.

[37]One could also examine the size of the absolute forecast errors, on average, instead of the ratio. For the post-1984 period, the mean absolute one-step forecast error for the level of unemployment with the dynamic model is 0.14; the four-step average is 0.36. For the simple difference version of Okun's law with varying

coefficients, the one-step mean forecast error is 0.15, and the four-step mean is 0.42. For the baseline model, the one-step mean is 0.17, and the four-step mean is 0.43. These results are in line with the earlier finding that—even with varying coefficients—Okun's law has not always been a tight statistical relationship.

[38]While Okun cited wide support among the economics profession for his 4 percent assumption, he acknowledged that one could conceivably choose a different U^F, and that doing so would change the estimated result. Economists now typically believe that U^F has varied over time, partly because of the demographic factors cited in Section II. As a result, this paper uses the more general notation.

[39]This maintains Okun's definition of the output gap. Most economists now write the output gap as actual output minus potential output, in natural-log terms; thus d would be negative.

[40]See also Weber (1995) and Lee (2000). One alternative approach among many is to estimate one of the unobserved series and then impose Okun's law in gap form to derive an estimate of the second unobserved series, as in Grant (2002); Mishkin (2007) discusses some of the shortcomings of such an approach.

Notably, the Congressional Budget Office (CBO) uses a variant of this technique in its estimates of potential real output. The CBO equates the natural rate of unemployment to the non-accelerating inflation rate of unemployment (NAIRU) and estimates the latter via a Phillips curve. Rather than relating the unemployment gap to the output gap directly as the above version of Okun's law would suggest, the CBO employs a production-function approach (see Section I) wherein output is a function of labor, capital, and total factor productivity, and where labor comprises the labor force, employment, and average hours worked. The CBO assumes that the unemployment gap is proportional to the gap between the labor force and its potential rate; proportional to the gap between average weekly hours worked and their potential rate; and proportional to the gap between total factor productivity and its potential rate. In each case, the factors of proportionality—while calculated separately for each relationship—are assumed to be constant across time. See CBO (2001).

[41]The figure shows the rolling regression coefficient when the potential output series uses the standard 1,600 smoothing parameter and the full-employment unemployment rate uses a smoothing parameter of 64,000. Varying the smoothing parameters does not materially affect the results. For each rolling regression, both series are re-filtered using the data that would have been available at that time; in this way, the HP filter does not use data beyond the end of the moving window in the regressions. However, the filter does use the available real-time data prior to the moving window to mitigate beginning-of-sample problems. See Lee (2000) for various filtering techniques and more on the discussion of whether economists should *a priori* link the natural rate of unemployment and potential output or not.

REFERENCES

Altig, David, Terry Fitzgerald, and Peter Rupert. 1997. "Okun's Law Revisited: Should We Worry About Low Unemployment?" Federal Reserve Bank of Cleveland, *Economic Commentary*.

Attfield, Clifford, and Brian Silverstone. 1997. "Okun's Coefficient: A Comment," *Review of Economics and Statistics*, vol. 79, no. 2, pp. 326–29.

Blanchard, Olivier. 2006. *Macroeconomics*. Upper Saddle River, N.J.: Prentice Hall, 4th ed.

Blanchard, Olivier, and Jordi Galí. 2006. "A New Keynesian Model with Unemployment," National Bank of Belgium, Working Paper Research No. 92.

Braun, Steven N. 1990. "Estimation of Current-Quarter Gross National Product by Pooling Preliminary Labor-Market Data," *Journal of Business and Economic Statistics*, vol. 8, no. 3, pp. 293–304.

Clark, Todd E., and Michael W. McCracken. 2006. "Forecasting with Small Macroeconomic VARs in the Presence of Instabilities," Federal Reserve Bank of Kansas City, Research Working Paper 06–09.

Congressional Budget Office. 2001. "CBO's Method for Estimating Potential Output: An Update," Congress of the United States.

Cuaresma, Jesús Crespo. 2003. "Okun's Law Revisited," *Oxford Bulletin of Economics and Statistics*, vol. 65, no. 4, pp. 439–51.

Gordon, Robert J. 1984. "Unemployment and Potential Output in the 1980s," *Brookings Papers on Economic Activity,* no. 2, pp. 537–64.

Grant, Alan P. 2002. "Time-Varying Estimates of the Natural Rate of Unemployment: A Revisitation of Okun's Law," *Quarterly Review of Economics and Finance*, vol. 42, pp. 95–113.

Kennedy, Peter. 2003. *A Guide to Econometrics*. Cambridge, Mass.: MIT Press, 5th ed.

Lee, Jim. 2000. "The Robustness of Okun's Law: Evidence from OECD Countries," *Journal of Macroeconomics*, vol. 22, no. 2, pp. 331–56.

McConnell, Margaret M., and Gabriel Perez-Quiros. 2000. "Output Fluctuations in the United States: What Has Changed Since the Early 1980s?" *American Economic Review*, vol. 90, no. 5, pp. 1464–76.

Mishkin, Frederic S. 2007. "Estimating Potential Output," speech at the Conference on Price Measurement for Monetary Policy, Federal Reserve Bank of Dallas, Dallas, Texas.

Montgomery, Alan L., Victor Zarnowitz, Ruey S. Tsay, and George C. Tiao. 1998. "Forecasting the U.S. Unemployment Rate," *Journal of the American Statistical Association*, vol. 93, no. 442, pp. 478–93.

Moosa, Imad A. 1997. "A Cross-Country Comparison of Okun's Coefficient," *Journal of Comparative Economics*, vol. 24, no. 3, pp. 335–56.

Okun, Arthur M. 1962. "Potential GNP: Its Measurement and Significance," American Statistical Association, *Proceedings of the Business and Economics Statistics Section*, pp. 98–104.

Prachowny, Martin F. J. 1993. "Okun's Law: Theoretical Foundations and Revised Estimates," *Review of Economics and Statistics*, vol. 75, no. 2, pp. 331–36.

Rudebusch, Glenn D. 2000. "How Fast Can the New Economy Grow?" Federal Reserve Bank of San Francisco, *Economic Letter* 2000-05.

Schreft, Stacey L., and Aarti Singh. 2003. "A Closer Look at Jobless Recoveries," Federal Reserve Bank of Kansas City, *Economic Review*, Second Quarter, pp. 45–73.

_____, and Ashley Hodgson. 2005. "Jobless Recoveries and the Wait-and-See Hypothesis," Federal Reserve Bank of Kansas City, *Economic Review*, Fourth Quarter, pp. 81–99.

Shimer, Robert. 2005. "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, vol. 95, no. 1, pp. 25–49.

Silvapulle, Paramsothy, Imad A. Moosa, and Mervyn J. Silvapulle. 2004. "Asymmetry in Okun's Law," *Canadian Journal of Economics*, vol. 37. no. 2, pp. 353–74.

Smets, Frank, and Raf Wouters. 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association*, vol. 1, no. 5, pp. 1123–75.

Sogner, Leopold, and Alfred Stiassny. 2002. "An Analysis on the Structural Stability of Okun's Law—A Cross-Country Study," *Applied Economics*, vol. 14, pp. 1775–87.

Summers, Peter M. 2005. "What Caused the Great Moderation? Some Cross-Country Evidence," Federal Reserve Bank of Kansas City, *Economic Review*, Third Quarter, pp. 5–32.

Weber, Christian E. 1995. "Cyclical Output, Cyclical Unemployment, and Okun's Coefficient: A New Approach," *Journal of Applied Econometrics*, vol. 10, no. 4, pp. 433–45.