Regional Tests of Okun's Law

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"Okun's law" describes an enduring empirical observation first made by Arthur Okun, relating departures from the natural rate of unemployment to changes in real output. This paper employs a recent development in trend-cycle decomposition of economic time series to measure the Okun coefficient using U.S. national and regional data. The key finding of this paper is that the value of the coefficient measuring the change in real output per unit of change in the unemployment rate, both measured as departures from equilibrium, is stable at a value of about 2 for all time periods and across regions of the U.S., irrespective of the method used to measure equilibrium output and employment. (JEL E32)

Introduction

Arthur Okun [1962, p. 99] observed that "in the postwar period, on the average, each extra percentage point in the unemployment rate above four percent [that is, his estimate of what we would now refer to as the natural rate of unemployment] has been associated with about a three percent decrement in real GNP." Because Okun's empirical finding held up well during the ensuing decade, the 3:1 trade-off between real gross national product (GNP) growth and the unemployment rate became known as Okun's law. Since that time, a number of papers have established theoretical foundations for Okun's law [Clark, 1983; Gordon, 1984; Prachowny, 1993] and tested the stability of the 3:1 trade-off [Clark, 1983; Gordon, 1984; Adams and Coe, 1989; Holloway, 1989; Prachowny, 1993; Attfield and Silverstone, 1998]. In general, Okun's law has withstood most challenges, although current estimates of the trade-off fall into a range closer to 2:1 than 3:1 [Gordon, 1984; Attfield and Silverstone, 1998; Moosa, 1997] and vary according to the methods and specifications used. Variations notwithstanding, the stability of Okun's law contrasts favorably with the Phillips curve, its counterpart in the unemployment-inflation space.[1]

Because of the way that Okun's law is framed, tests of its proposition involve two imposing empirical problems. First, the law refers to departures of real gross domestic product (GDP)[2] and unemployment from their long-run or equilibrium trends, with the latter often referred to as potential GDP and the natural rate of unemployment, respectively. These equilibrium trends must be estimated either by time series methods [Moosa, 1997] or by construction using a modified production function approach in which potential output is estimated using fully employed inputs [Gordon, 1984; Adams and Coe, 1989]. Either approach invites considerable criticism of assumptions and

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methods,[3] and there is likely to remain substantial measurement error in any computation of potential or long-run quantities. Further, the latest year of observation for these constructed data sets is 1988 when the natural unemployment rate was estimated by Gordon [1997] to be in excess of 6.0 percent, well above the levels we have experienced with stable to declining inflation in the mid to late 1990s.

Second, in formulating his law, Okun clearly seems to be referring not to a *ceteris paribus* relationship between changes in the unemployment rate and changes in real GDP. Writing later, Okun [1970, p. 140] assumed that other factors and inputs would be changing *pari passu* with employment: "The 3 percent result [from a reduction of 1 percent in the unemployment rate] implies that considerable output gains in a period of rising utilization rates stem from some or all of the following: induced increases in the size of the labor force; longer average weekly hours; and greater productivity." Thus, an appropriate specification of the effect of changing unemployment rates on output would include factors such as capital inputs, labor hours, and participation rates, all measured as deviations from long-run trends. Because the levels of these variables are extremely difficult to measure, let alone their potential values, attempts to include them in tests of Okun's law have produced mixed results [Prachowny, 1993; Attfield and Silverstone, 1997].

This paper addresses these two obstacles by using a recent trend-cycle decomposition developed by Baxter and King [1995] to measure output and employment gaps and by using a reduced-form specification which assumes that the other factors responsible for output changes are so highly colinear with the unemployment gap that separate measures are not possible, an assumption made plain by Okun. The Baxter and King bandpass filter addresses many of the problems of extracting the trend component of economic time series by providing a flexible and easy to implement method that eliminates both high frequency (those less than two years) and low frequency (more than eight years) fluctuations. The Baxter and King procedure is described in greater detail in the following section.

Okun's law is tested using data for the U.S. and for the eight U.S. regional economies as defined by the Bureau of Economic Analysis for the periods 1958-98 (for quarterly U.S. data) and 1977-97 (using annual GDP and gross state product (GSP)). More recent data will provide evidence on whether the Okun coefficient has continued to decline from the value of 3.0, estimated by Okun to the value of 2.0 to 2.25 and estimated using the Gordon and Adams and Coe data sets terminating in the 1980s. The use of regional data will provide both additional evidence on the magnitude of the coefficient and on regional differences in the responsiveness of output to reductions in unemployment.

Using regional data to measure Okun's coefficient is apparently new,[4] and has the potential to uncover geographic differences in the responsiveness of labor markets to changes in output. Furthermore, the greater variation in output and unemployment at the regional level may allow for more efficient parameter estimation.

This paper's key findings are that the value of Okun's coefficient, estimated from cyclical gaps generated by the bandpass filter, is remarkably stable at about 1.9 to 2.0 for the overall economy for the entire 1959-98 period and that values for the regions vary within a broader range, from 1.8 to 3.6, with a weighted average of 2.22. Pooled estimation of the entire sample also resulted in an estimate of 2.22.

This paper proceeds as follows. The second section describes the bandpass filter and presents business cycles for the national economy and the eight regional economies. The third section presents the results of ordinary least squares (OLS) estimates of Okun coefficients using the filtered data. The fourth section concludes.

Estimating Gaps Using Bandpass Filters

The simplest statement of Okun's law can be expressed as:

$$y - y^* = -\beta(u - u^*) \quad , \tag{1}$$

where y is output, measured in natural logarithms, u is the unemployment rate, measured in percentage, and starred variables refer to equilibrium values, usually potential or long-run trend output and the natural or full-employment unemployment rate. The differences between actual and equilibrium values are called gaps. β is the Okun coefficient, estimated originally by Okun as approximately 3. Recent estimates of Okun's coefficient have relied on equilibrium series on output and unemployment as estimated by Adams and Coe [1989] and Gordon [1984, 1997] (also, see Prachowny [1993] and Attfield and Silverstone [1997]).

Unfortunately, both sets of equilibrium series terminated in the late 1980s, and no similar estimates have been attempted for U.S. regional economies for any time periods. However, Moosa [1997] recently examined cross-country estimates of Okun's coefficients and found a stable value of 2.2 for the U.S. using time series estimates of equilibrium output and employment over the period 1960-95. This value is quite close to Attfield and Silverstone's [1997, Table 3] estimate of 2.27 which uses Gordon's calculated equilibrium series. Therefore, there is some evidence that estimates of (1) may be robust to the method of computing gaps, so long as the gaps on both sides of (1) are computed consistently.

Gaps may also be viewed as the cyclical components of the output and unemployment series. Using this approach, the problem is the classical decomposition of a time series into its various components: trend, cycle, seasonal, and irregular. Modern macroeconomic empirical work offers a number of alternatives to the separation of trends and cycles in economic time series, including removing linear or quadratic trends, first differencing, or more complex filters such as those of Hodrick and Prescott [1997] or Beveridge and Nelson [1981]. Recently, Baxter and King [1995] have advanced a "bandpass" filter that is designed to filter out all frequencies outside a band of two to eight years, limits originally advanced by Burns and Mitchell [1946] for business cycle duration. The advantage of the bandpass filter over its counterparts is that it filters out both the high frequency fluctuations (for example, irregular components) in the series, which typically remain after first differencing, and the low frequency fluctuations (for example, autocorrelation), which remain after taking deterministic trends or applying the

Hodrick and Prescott filter. The bandpass filter has been used to extract cyclical components of macroeconomic time series by Stock and Watson [1998] and Basu and Taylor [1999].[5]

Figure 1 displays the cyclical components of regional GSP and unemployment for the eight regions,[6] as defined by the Bureau of Economic Analysis, and total U.S. for the period 1977-97. Because the filter is a centered moving average, the first three and last three data points are lost to the averaging technique.[7]

In general, the effectiveness of the bandpass filter is indicated by the centering of the cyclical components around 0 and by the close correspondence of the cyclical components with the national recessions, as identified by the National Bureau on Economic Research, and shown as the shaded areas in Figure 1.[8] Regional differences in business cycles are likewise readily identified: the greater impact of the 1981-82 recessions on cyclical industrial and food-producing states in the Great Lakes and Plains states; the collapse of oil prices and consequent contraction in the oil-producing states of the Southwest and Rocky Mountain regions; and the high-tech boom of the late 1980s (the so called "Massachusetts Miracle") which was concentrated in New England and the Far West.

FIGURE 1
Regional Differences in Business Cycles

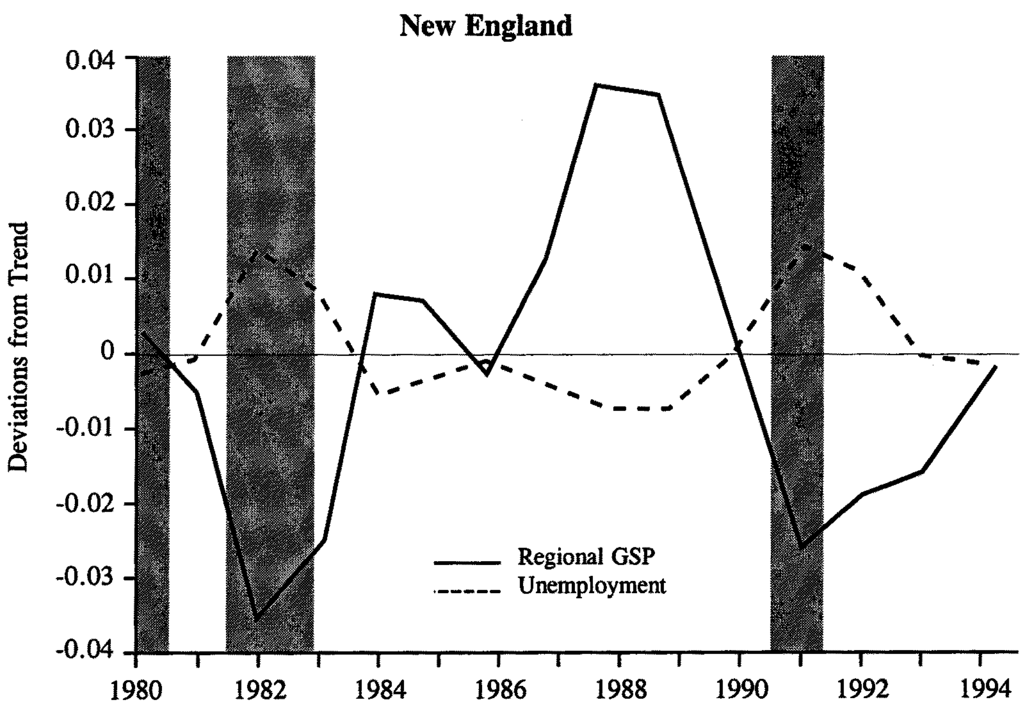
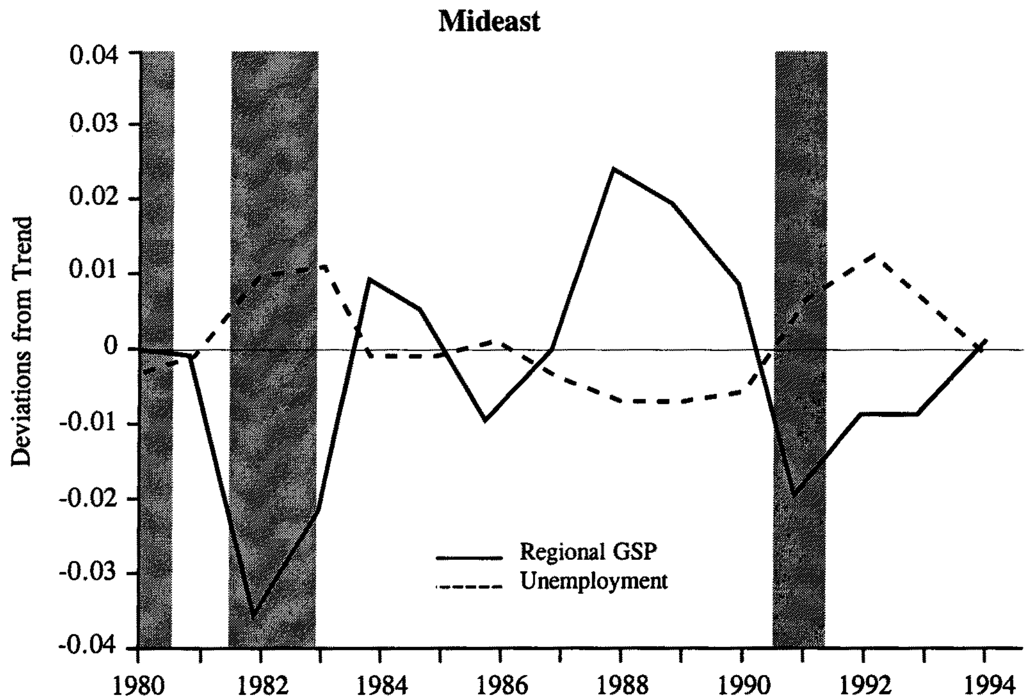


FIGURE 1 (CONT.)



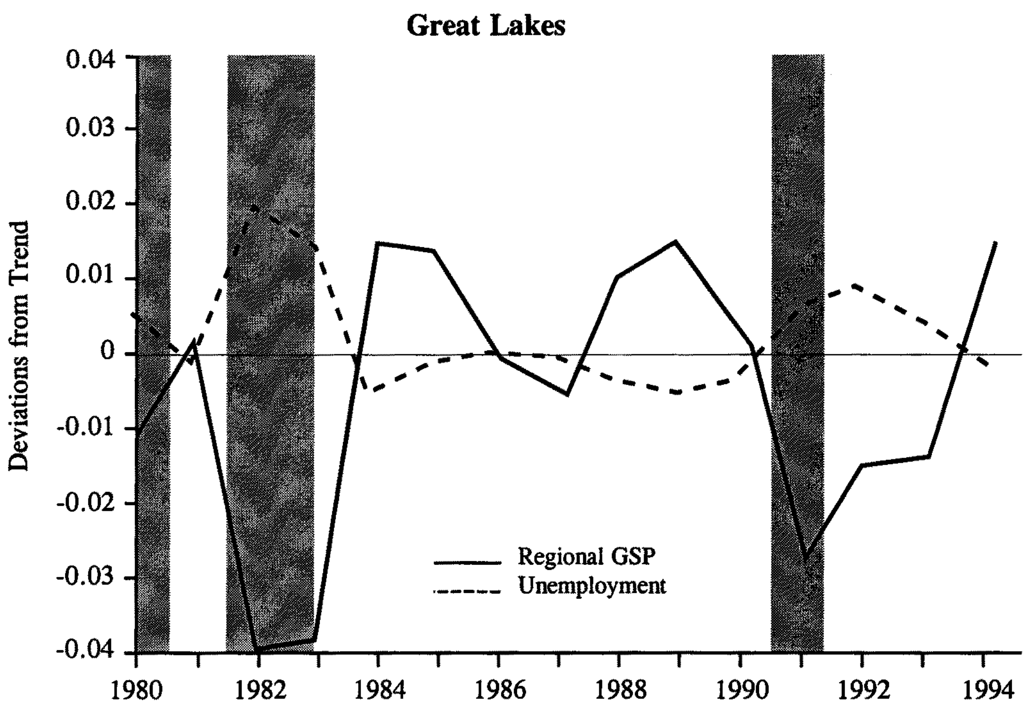
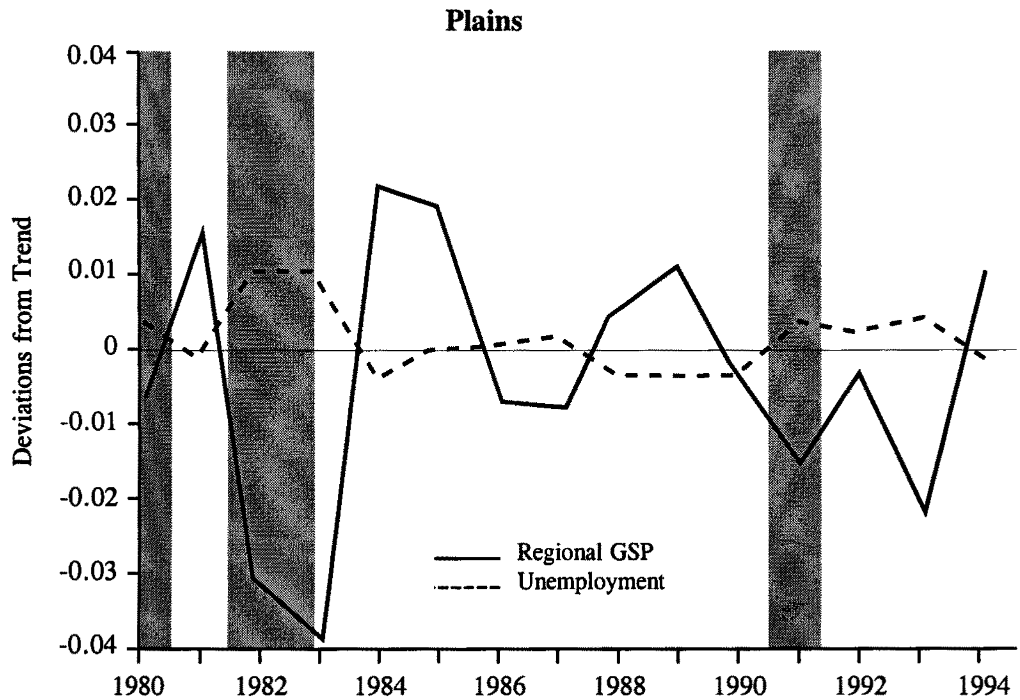


FIGURE 1 (CONT.)



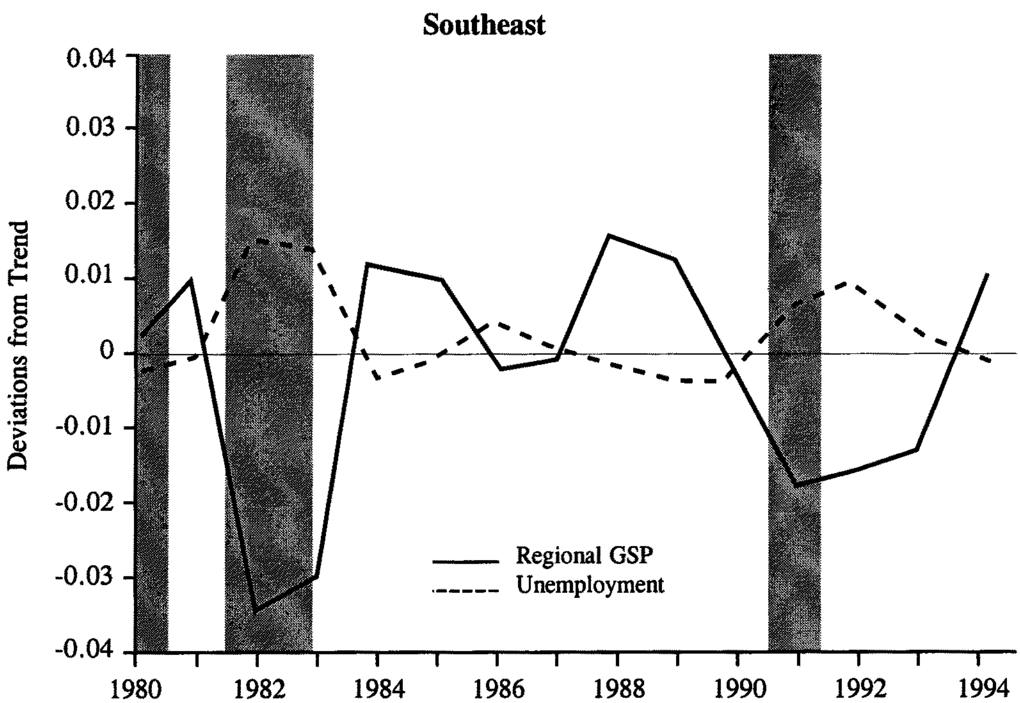
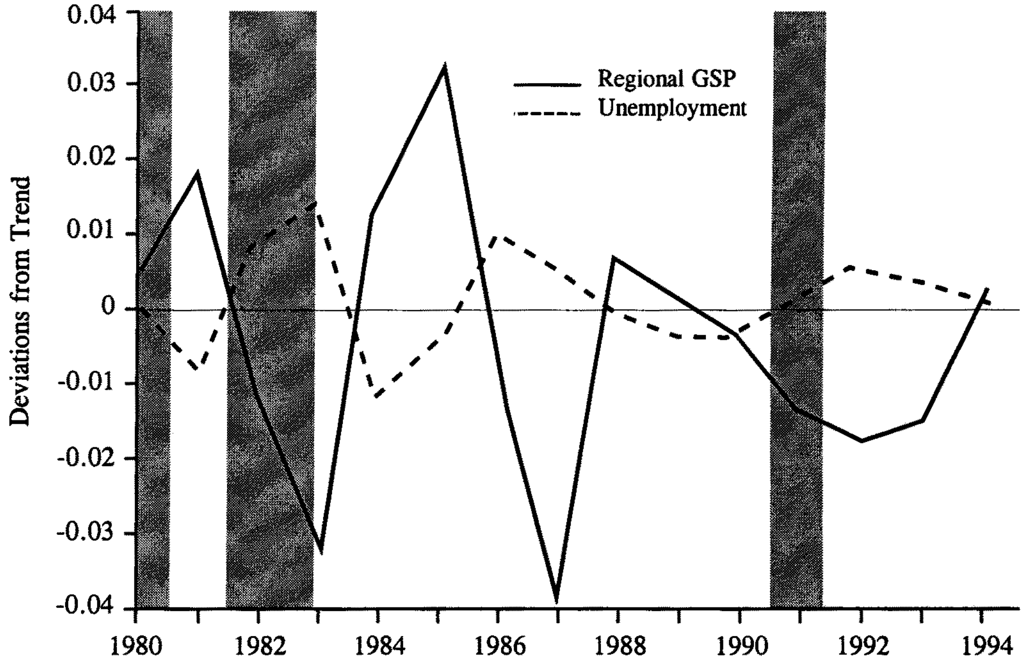


FIGURE 1 (CONT.)

Southwest



Rocky Mountain

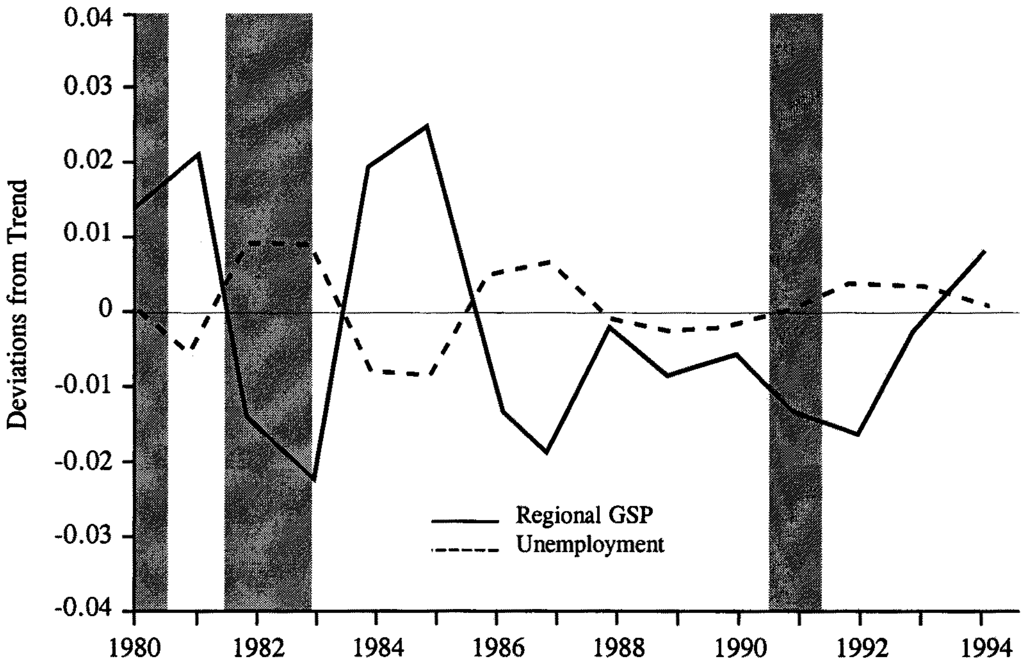
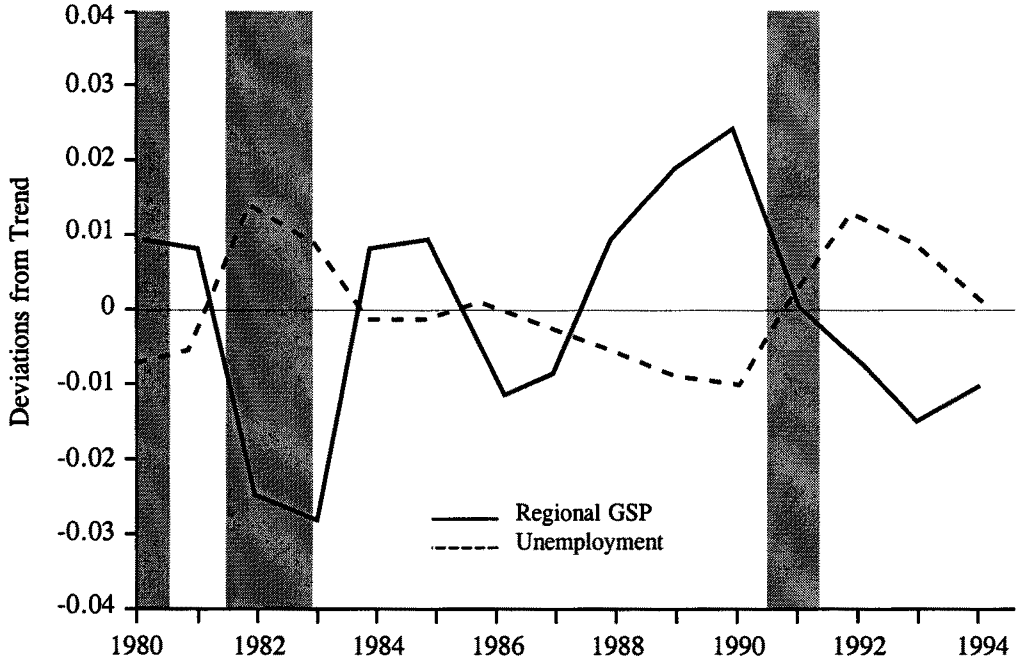
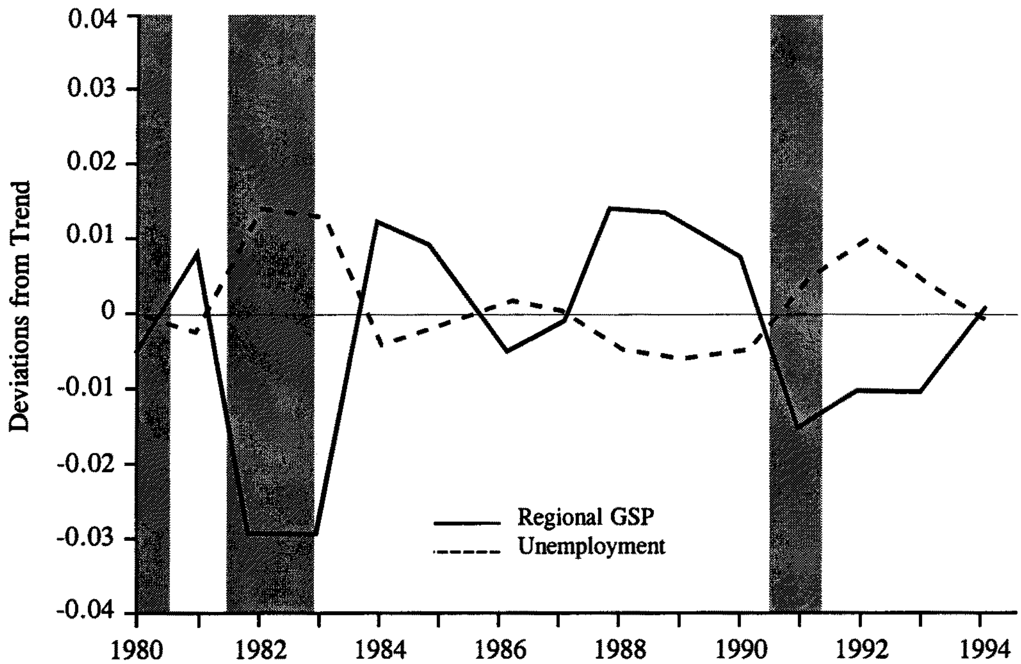


FIGURE 1 (CONT.)

Far West



United States



More particular to the estimation of Okun coefficients, the output and unemployment series tend to cross close to the 0 line, indicative of the coincident equilibrium that one would expect from the two series. Further, the amplitude of the output series is considerably larger than that of the unemployment series, as Okun's model would predict. These extracted cyclical components will be used to test Okun's law in the next section.

Estimating Okun's Coefficient for Regional Economies

The availability of consistent estimates of GSPs from the Bureau of Economic Analysis limits the regional estimates of (1) to annual data over the period 1977-97. As a check of the methodology, quarterly and annual data for the national economy, detrended using the bandpass filter, are first estimated for the period 1959-98, and the stability of the estimated coefficients are checked by dividing the national series into subsamples. The results of the national estimates are reported in Table 1.

TABLE 1
Estimates of Okun's Coefficient for Annual and Quarterly Data for the U.S. Economy from 1959 to 1998: $y - y^* = -\beta_i(u - u^*)$

	Sample Periods			
	Full: 1959-97 (β_F)	Sub 1: 1959-77 (β_1)	Sub 2: 1978-97 (β_2)	Chow Test H_0: $\beta_F = \beta_1 = \beta_2$
Annual Data				
Bandpass Filter				
β_i	1.99 (0.167)	1.96 (0.297)	2.02 (0.175)	0.28
R^2	0.82	0.74	0.89	
DW	2.15	2.02	2.44	
Quadratic Trend*				
β_i	1.91 (0.105)	1.82 (0.170)	2.03 (0.117)	0.83
R^2	0.90	0.86	0.94	
DW	1.48	1.42	1.71	
Quarterly Data				
Bandpass Filter				
β_i	1.99 (0.001)	2.05 (0.002)	1.92 (0.001)	0.59
R^2	0.80	0.88	0.80	
DW**	1.56	1.54	1.65	

TABLE 1 (CONT.)

	Sample Periods			
	Full: 1959-97 (β_F)	Sub 1: 1959-77 (β_1)	Sub 2: 1978-97 (β_2)	Chow Test H_0: $\beta_F = \beta_1 = \beta_2$
Quadratic Trend*				
β_i	2.02 (0.001)	1.98 (0.001)	2.08 (0.001)	0.66
R^2	0.87	0.86	0.88	
DW**	1.74	1.66	1.75	

Notes: * Figures are estimated using residuals from the regression of $x_t = a + bt + ct^2$, where x_t is alternatively the natural log of GDP (for the output gap) and the unemplyment rate. ** Figures are computed as differences over four quarters. DW denotes Durbin Watson statistics. Standard errors are in parentheses.

TABLE 2
Estimates of Okun's Coefficient for Annual Data for U.S. Regions from 1977 to 1997: $y - y^* = -\beta_i(u - u^*)$

Regions	Bandpass Filter		Quadratic Trend	
New England	2.31	(0.003)	2.45	(0.004)
Mideast	1.95	(0.003)	2.20	(0.003)
Great Lakes	2.53	(0.002)	1.86	(0.002)
Plains	3.57	(0.004)	1.74	(0.004)
Southeast	2.21	(0.002)	1.85	(0.002)
Southwest	1.95	(0.004)	1.31	(0.007)
Rocky Mountain	2.28	(0.005)	-0.03	(0.012)
Far West	1.84	(0.002)	2.09	(0.002)
Regional Average*	2.22		1.87	
Pooled Sample**	2.25	(0.510)	1.92	(1.230)

Notes: * Figures are computed using GSP weights. ** Figures are computed using the F-test of slope homogeneity. Standard errors are in parentheses.

OLS regressions of quarterly and annual data consistently estimate the Okun coefficient at a value of 2.[9] Further, the results are robust to the choice of time period and detrending methodology, and the DW statistics show no evidence of serial correlation. These results contrast with those of Prachowny [1993] and Attfield and Silverstone [1997] who find evidence that output and unemployment gaps computed from the Gordon and Adams and Coe datasets are $I(1)$ and cointegrated.[10] The failure to reject nonstationarity in previous research may be due either to the methods used to construct the potential series or to the low power of unit root tests over short time intervals (only 15 years of quarterly data using the Adams and Coe series).

The near-identical result using the quadratic trend is something of a surprise given the prevailing belief (at least since Nelson and Plosser [1982]) that macroeconomic series are driven primarily by stochastic trends. Whether this result holds for other applications or is specific to (1) is worth considering but is beyond the scope of this study.

Turning to the regional data, the results of OLS regressions on output and employment gaps generated by the bandpass filter and the quadratic trends are reported in Table 2. The results of the regional tests are generally in line with national estimates with the exception of two regions, one in each detrending category. The Okun coefficient for the Plains region using the bandpass filter is about 50 percent larger than the regional average, reflecting the relatively small amplitude of the unemployment gap, as seen visually in Figure 1 and confirmed by the standard deviation of the gap, the smallest among all regions. Using the quadratic trend, the Okun coefficient for the Rocky Mountain region is not significantly different from 0. The prolonged slump of this region during the 1980s resulted in a positive coefficient on the quadratic term in the trend estimation, possibly distorting the result of the Okun estimation.

There is no obvious pattern to interregional differences in the magnitude of the Okun coefficients nor is there a close correspondence across the two detrending methods (the correlation coefficient for the two sets of coefficients is -0.03 with the Rocky Mountain region, -0.15 without). Thus, even though labor markets in the North and East are often described as being less flexible than markets in the South and West (implying larger values of the Okun coefficient for the former), there is no evidence of it here, at least as far as these reduced-form estimates are able to reveal.

Pooled estimation of the Okun coefficient using the eight regions yields estimates comparable to the national data in Table 1 and to estimates from previous research. The regional averages and the pooled estimates are quite similar in each category, and slope homogeneity cannot be rejected in either case.

Conclusion

Okun's law is one of the more enduring stylistic facts of U.S. macroeconomics, having withstood numerous tests in the almost four decades since it was first promulgated by Arthur Okun. While Okun's original estimate of a three-point increase in real output for every one-point decrease in unemployment has been reduced to 2.0-2.5 (perhaps a reflection of the larger service component of U.S. employment), this law continues to be cited as part of a set of core beliefs in macroeconomics, along with the short-run Phillips curve [Blinder, 1997]. As a rule of thumb, Okun's law provides policy makers with a rough guide to the employment effects of higher output growth.

The challenge of interpreting Okun's law, however, lies in the identification of the crucial quantities of potential output growth and the natural rate of unemployment, for these provide the equilibrium levels for what is, in essence, a disequilibrium relationship. Past attempts to estimate Okun's coefficient have employed deterministic trends, trend-cycle decompositions, and constructed measures of potential output and unemployment. This paper employs recent development by Baxter and King [1995] to extract the frequencies identified by Burns and Mitchell [1946] as typical of business cycles in the U.S. economy. The advantages of the "bandpass" filter of Baxter and King are that both high frequency (irregular) and low frequency (stochastic or deterministic trend) fluctuations are removed from the macroeconomic series. The remaining series appear to approximate Okun's gaps for output and employment.

This paper employs a set of data for the U.S. economy that is more recent than that of previous studies and, apparently for the first time, examines the question of whether Okun's coefficient exhibits regional differences. Previous estimates of a value of around 2 for Okun's coefficient are confirmed for national and regional data over a variety of time periods. There do not appear to be significant interregional differences in the response of output to changes in unemployment rates, and pooled estimates of regional data conform to national estimates using aggregate data.

It is important to emphasize that Okun's law is a statement regarding departures from equilibrium levels, not a general statement about the response of current output to current changes in unemployment. Properly measured, however, Okun's relationship continues to be perhaps the closest thing to a law that macroeconomics has.

Footnotes

1. Writing almost two decades later, however, and shortly before his death, Okun [1981, p. 228] himself doubted his law's stability: "During the late seventies, the three-to-one ratio [of real GNP to the unemployment rate] no longer approximated reality....If employers encounter an unusually deep recession and expect the subsequent period of slack to be especially long lasting, they are likely to cut back employment more nearly in proportion to the decline in output."
2. This paper follows the Bureau of Economic Analysis in making the transition to real GDP from real GNP since Okun's original work, but for the purposes of this paper, the measures are equivalent.
3. See, for example, the comments of Clark and Baily to Gordon [1984].
4. However, see Blackley [1991], who estimates Okun coefficients for 26 state economies. Blackley assumes a constant trend growth in potential output and makes no attempt to measure trend unemployment.
5. The bandpass filter is a centered moving average, $x_t^c = \sum_{k=-K}^{K} a_k x_{t-k}$, such that the weights, a_k, are chosen to minimize the squared difference between the optimal (where $K = \infty$) and approximately optimal weights. For annual series, the weights are 0.7741, -0.2010, -0.1351,

-0.0510 for $k = 0, 1, 2, 3$, respectively. Because $\sum_{k=-K}^{K} a_k = 0$, it can be shown that the filter renders stationary time series integrated of order 1 or 2. For details, see Baxter and King [1995].

6. The regions are called:
   1) New England, which includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont;
   2) Mideast, which includes Delaware, Washington D.C., Maryland, New Jersey, New York, and Pennsylvania;
   3) Great Lakes, which includes Illinois, Indiana, Michigan, Ohio, and Wisconsin;
   4) Plains, which includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota;
   5) Southeast, which includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia;
   6) Southwest, which includes Arizona, New Mexico, Oklahoma, and Texas;
   7) Rocky Mountain, which includes Colorado, Idaho, Montana, Utah, and Wyoming; and
   8) Far West, which includes Alaska, California, Hawaii, Nevada, Oregon, and Washington.
7. The loss of these data points is not as significant as it may seem. The filter effectively removes the need for differencing the data or for including lagged values in the OLS regressions that follow, both of which consume degrees of freedom in previous studies.
8. The actual dates of the recessions (business cycle peak to trough) are January to July 1980, July 1981 to November 1982, and July 1990 to March 1991.
9. Other specifications of (1), including lags of both dependent and independent variables, were tested, but in no case did any lagged variable have a significant effect on the results, using either t-statistics or Schwarz-Bayes information criterion.
10. Augmented Dickey-Fuller statistics and associated p-values for the quarterly gap series are as follows: -3.28 (0.019) for output and -3.96 (0.002) for unemployment, using the bandwidth filter, and -3.20 (0.02) for output and -3.09 (0.03) for unemployment, using the quadratic trend.

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