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Unemployment And The GNP Gap: Okun's Law Revisited

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INTRODUCTION

Okun's law is one of the widely used tools for policy makers to measure the cost of unemployment and the gain of economic growth.[1] It can be stated in several different ways. In one version, it describes the link between the GNP gap and the unemployment rate. According to Okun [1970, p. 137], the unemployment rate would decline by 0.3 percentage points if real output grew by 1 percentage point above potential output. He also indicated that the 0.3-to-1 link applied only to the sample with the unemployment rates between 3% and 7.5% and that the 0.3 coefficient might change when the unemplopyment rate was considerably lower or higher than this range. Okun's law has received evaluations and criticisms in recent years. Gordon [1984] found that there were long lags for unemployment to adjust to changes in real output and that Okun [1970] somewhat underestimated the parameter.[2] Dornbusch and Fischer [1987] indicated that the estimates of potential output and the link between unemployment and the GNP gap have changed in the long run and that it is "not an immutable law." Benjamin Friedman [1988] also expressed that Okun's law has not performed well during the 1980s.

An examination of previous studies reveals that the effect of a change in the GNP gap on the unemployment rate was usually assumed the same in the sample period. This may not be true. When the unemployment rate is greater than the natural rate of unemployment, an increase in real output is likely to have more effect on the unemployment rate due to excess labor supply. These surplus workers are available and can be hired readily at the existing wage rate. When actual real output is greater than potential real output, an increase in real output is going to have less effect on the unmeployment rate because it may be getting more difficult to hire additional workers at the current wage rate and because existing workers may be given more hours or overtime to produce extra output.[3] If we plot the unemployment rate and the GNP gap on the vertical and horizontal axes, respectively, the curve is likely to be steeper (flatter) when the unemployment rate is higher (lower).

The issue of functional form or the steepness/flatness of a curve is important in economic analysis. Smyth and Dua [1988] maintained that macroeconomic variables such as the unemployment rate and inflation rate may have nonlinear relationship and that the slope may vary with the values of the dependent and independent variables. There were also debates over the functional form of the Phillips curve (PC) in the early 1960s. Ehrenberg and Smith [1988] also implied that in recent years the PC has become flatter due mainly to downward wage rigidity.

The purpose of this study is to reexamine Okun's law and to test the propostion that the relationship between the GNP gap and the unemployment rate does not remain the same, but varies with the levels of the variables. Major findings in this study will have significant policy implications since the estimated parameter may help policy makers analyze the link between changes in output and unemployment more accurately.

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THE MODEL

The relationship between output and unemployment can be estimated in several ways. The first method is to express the change in the unemployment rate as a function of the change in real GNP. The second version is to specify that the unemployment rate is a function of the GNP gap. The third alternative derives the output/unemployment relationship without relying on the trend estimates. We first regress the employment rate on real GNP and a time trend with the first two variables expressed in the log form. By so doing, the output elasticity of the employment rate can be obtained, and the unemployment rate equals 100 minus the employment rate. The last method is the so-called components approach [see Sheehan and Zahn, 1980]. The linkage between unemployment and output can be broken down into several components, some of which such as the labor force participation rates, average weekly hours, and real GNP can be estimated. The advantage of this approach is that the Okun coefficient may vary over time due to changes in the components. In this study, the second method is employed partly because Gordon [1987] chose this version to describe Okun's law and partly because of the flexibility of the equation for the study of different functional forms.[4] Applying the Box-Cox extended autoregressive (BCEA) model of Savin and White [1978],[5] we can express the estimated equation as:

$$Ut^{**} = \beta_1 + \beta_2 Gt^{**} + \beta_3 U^{**}t\text{-}1 + Vt \qquad (1)$$

where

$$Ut^{**} = Ut^{*} - \rho\ U^{*}t\text{-}1$$

$$Ut^{*} = (U_t^{\delta} - 1)/\delta$$

$$Gt^{**} = Gt^{*} - \rho\ G^{*}t\text{-}1$$

$$Gt^{*} = (G_t^{\delta} - 1)/\delta$$

U is the unemployment rate, G is the GNP gap or the ratio of actual to potential real GNP, V is the disturbance term, t is time, δ is the Box-Cox transformation parameter, and ρ is the first-order autoregressive parameter. A lagged dependent variable is added to equation (1) to incorporate the partial adjustment process, because it may take more than one period for the actual Ut to adjust to the desired level.[6] Note that equation (1) reduces to a linear form when δ equals 1.0 and becomes a double-log form when δ approaches 0. The advantage of the Box-Cox [1964] model is that it can test whether a specific functional form is appropriate. If the linear form is rejected, the slope will not remain the same. If the double-log form assuming constant elasticity is rejected, the elasticity will vary with the levels of the dependent and independent variables. In empirical work, we first regress Ut** on Gt** and $U_t^{**}{}_{-1}$ over different values of δ and ρ. The maximum likelihood method is employed to estimate the value of the log-likelihood function. The likelihood ratio (LR) test of the null hypothesis with restrictions on the parameters versus the alternative hypothesis can determine whether the linear form is appropriate.[7]

EMPIRICAL RESULTS

The sample consists of quarterly data for the U.S. during 1954.2-1988.2. Ut came from Monthly Labor Review, the Bureau of Labor Statistics, U.S. Department of Labor. Actual real GNP in 1982 dollars was obtained from the Survey of Current Business, Bureau of Economic analysis, U.S. Department of Commerce. Potential real output before 1986.3 was taken from Gordon [1987, pp. 584-587]. After 1986.2, potential real output was calculated based on a quarterly growth rate of 0.65% as assumed by Gordon [1987]. Note that potential GNP can also be directly estimated [see Clark, 1983]. Using Gordon's [1987] series is because his methodology is sound, the data are available, and empirical results between this study and others can be compared easily.

Estimated regressions and other relevant statistics for the BCEA model and the linear form are presented in Table 1.[8] As shown, the unemployment rate and the GNP gap are highly correlated because the coefficient of G_t^{**} is significant at the 1% level in both functional forms. It appears that the incorporation of the partial adjustment model is also appropriate due to the significance of the lagged dependent variable in both regressions. Note, however, that the adjustment process is not sluggish. It is calculated that about 84% of the long-run effect is realized within the first year. In the BCEA model, the estimated values of δ and ρ are 0.19 and 0.67, respectively. It seems that functional form and autocorrelation should be tested simultaneously because the estimated value of δ is different from unity as assumed in the linear case and because ρ is significant at the 1% level.

To see whether the linear form is appropriate, consider testing Ho: $\delta = 1$ versus Ha: $\delta = 1$ or the linear form versus the BCEA model. The value of the test statistic equals 18.88. The critical value is 6.635 at the 1% level with one degree of freedom. Since the value of the test statistic is greater than the critical value, the null hypothesis that Ho $\delta = 1$ can be rejected in favor of the BCEA model.

Table 1 also presents estimated regressions based on annual data from 1930 to 1985 to measure the long-run magnitude of dUt/dGt during the Great Depression and World War II.[9] Again, the linear form can be rejected at the 1% level in favor of the BCEA model. The long-run effect of dUt/dGt was calculated to be -1.07 in 1933 when the unemployment rate of 25.2% was at its record high. The long-run effect was -0.07 in 1944 with the lowest recorded unemployment rate of 1.2%. Thus, using annual data including the depression and war years also yield similar results.

The short-run effect of the change in Gt on Ut can be shown as

$$dU_t/dG_t = -2.115(U_t)^{0.81}(G_t)^{-0.81} \qquad (2)$$

where 0.81 is calculated from 1 - δ and -0.81 is obtained from δ - 1. Note that the derivative of Ut with respect to Gt is not a constant but depends on the values of β_2, Ut, Gt and δ. If $\delta < 1$, dUt/dGt varies positively with the value of Ut and negatively with the value of Gt. When $\delta = 1$, dUt/dGt reduces to β_2 or -2.115 in this case. Table 2 compiles estimated long-run effects of changes in Gt on Ut. To save space, only effects for selected quarters are reported. The effects varied from -0.280 in 1969.1 to -0.801 in 1982.4. Since the end values of the effects are greater than twice the value of the standard error, the null hypothesis of a constant slope can be rejected. In the linear form, the long-run effect is calculated to be -0.468. If the linear form is chosen a priori, it would underestimate the effects during the early 1980s and overestimate the effects during the late 1960s. In fact, the long-run effects were smaller than 0.30 in absolute value during 1968.2-1969.3 when actual real GNP was greater than potential real GNP. On the other hand, the long-run effects were greater than 0.70 in absolute value during 1982.2-1983.3 when unemployment rates were between 9.4% and 10.7%.[10] Thus, empirical results have confirmed the proposition that the effect of changes in the GNP gap on the unemployment rate is greater (smaller) when the unemployment rate is higher (lower).[11]

To compare possible different results which may be obtained from the BCEA model and the linear form, the fourth quarter of 1982 is selected for illustrative purpose. In 1982.4, the actual unemployment rate was 10.7%, actual real GNP in 1982 dollars was $3159.3 billion, and potential real GNP was $3490.2 billion. The GNP gap expressed in percentage points was 90.52 (3159.3 / 3490.2 x 100). Based on the linear form, to reduce Ut by 1 percentage point, the GNP gap is expected to increase by 2.14 to 92.66, and actual real GNP will rise to $3234.0 billion. Under the BCEA model, when Ut drops by 1 percentage point, the GNP gap will only increase by 1.25 percentage points to 92.77, and actual real GNP will rise to $3203 billion. Therefore, to reduce the unemployment rate by 1 percentage point, we may overestimate the increase in actual real GNP by as much as $31 billion if the linear form is chosen a priori for policy decision making. The difference is large enough for policy makers to reexamine the link between the GNP gap and the unemployment rate.

TABLE 1

estimated Regressions Of The Unemployment Rate On The Gnp Gap For The U.S.

	Quarterly Data		Annual Data	
Independent variables	(A) BCEA	(B) Linear	(C) BCEA	(D) Linear
GNP gap	-2.115 (-11.356)	-0.224 (-11.173)	-1.873 (-12.478)	-0.243 (-7.231)
Lagged Ut	0.532 (12.531)	0.521 (11.841)	0.109 (1.715)	0.303 (3.596)
Intercept	16.492 (11.543)	24.362 (11.506)	19.104 (13.136)	28.236 (7.785)
$\overline{R}^2$	0.981	0.979	0.963	0.942
Durbin's h	-1.86	-1.31	0.45	1.60
δ	0.19	1.00	0.27	1.00
ρ	0.67 (10.56)	0.70 (11.47)	0.67 (6.75)	0.70 (7.34)
$G(\delta,\rho)$	17.14	7.70	-67.33	-96.77

BCEA is the Box-Cox extended autoregressive model. $G(\delta,\rho)$ is the log-likelihood function. Figures in parentheses are t-ratios. Versions (A) and (B) were estimated with quarterly data during 1954.2-1988.2. Versions (C) and (D) were estimated with annual data over the period 1930-1985.

Theoretically, the standard error for δ can be estimated based on equation (11) in Spitzer [1984]. It is not reported because the software package does not estimate it and because we lack the expertise to write a very sophisticated program to calculate it.

CONCLUSIONS

The relationship between output and unemployment has been reexamined empirically. The Box-Cox extended autoregressive model is applied to the U.S. sample to regress the unemployment rate on the GNP gap during 1954.2-1988.2. Major findings in this study are: (1) the linear form assuming constant slope can be rejected in favor of the BCEA model; (2) estimated long-run effects of changes in the GNP gap on the unemployment rate varied from -0.280 in 1969.1 to -0.801 in 1982.4; and (3) the effect is greater (smaller) when the unemployment rate is higher (lower).

Relying upon the variable effects found in this study, policy makers would not underestimate dUt/dGt during recessions and overestimate dUt/dGt during inflationary periods. For instance, in 1969.1, Gt has to rise by 3.57 percentage points for us to reduce Ut by 1 percentage point due mainly to the facts that actual

TABLE 2

Long-run Effects Of Changes In The Gnp Gap On The Unemployment Rate

Year and quarter	Effect	Year and quarter	Effect
1954.4	-0.418	1971.4	-0.462
1955.4	-0.340	1972.4	-0.418
		1973.4	-0.380
1956.4	-0.337	1974.4	-0.515
1957.4	-0.400	1975.4	-0.624
1958.4	-0.497		
1959.4	-0.445	1976.4	-0.589
1960.4	-0.500	1977.4	-0.513
		1978.4	-0.451
1961.4	-0.483	1979.4	-0.466
1962.4	-0.438	1980.4	-0.564
1963.4	-0.438		
1964.4	-0.397	1981.4	-0.623
1965.4	-0.327	1982.4	-0.801
		1983.4	-0.645
1966.4	-0.301	1984.4	-0.560
1967.4	-0.315	1985.4	-0.537
1968.4	-0.282		
1969.4	-0.301	1986.4	-0.527
1970.4	-0.455	1987.4	-0.448
		1988.2	-0.435

Mean = -0.464 and standard error = 0.114.

Long-run effect = $[\beta_2/(1-\beta_3)][G_t/U_t]^{\delta-1}$ where $dU_t/dG_t = \beta[G_t/U_t]^{\delta-1}$ is the short-run effect and β_3 is the coefficient of the lagged dependent variable.

real GNP was greater than potential real GNP and that the economy was operating at an Ut of 3.4% compared to the assumed natural Ut of 5.6%.[12] In contrast, in 1982.4, in order for us to reduce Ut by 1 percentage point, Gt needs only to increase by 1.25 percentage points because large numbers of unemployed labor force were available and ready to work.

There are several potential areas for further research. Empirical results in this study depend partly upon the estimates of potential real GNP. It is expected that different estimates of potential real GNP may yield different results. Equation (1) may include other variables to see whether the link between the unemployment rate and the GNP gap has shifted in recent years. The BCEA model may be expanded to cover more specific functional forms.

NOTES

1 See Abraham and Katz [1986], Akerlof and Yellen [1988], Brown [1983], Clark [1983], Gordon [1984], Okun [1970], and Rima [1986] for analyses of unemployment and other empirical models estimating the unemployment rate. Abraham and Katz [1986] found that aggregate demand disturbances rather than sectoral shifts were the major cause of cyclical fluctuations in unemployment. Akerlof and Yellen [1988] analyzed the fair wage/effort hypothesis associated with the efficiency wage model. Brown [1983] examined unemployment policies from the Truman to the Carter years and the evolution of unemployment theories including the institutional vs. neoclassical view, deficient aggregate demand, rational unemployment, natural rate of unemployment, search theory, and turnover unemployment.

2 According to Gordon [1984, P. 548], when the GNP gap rises by 1 percentage point, the unemployment gap declines by 0.492 percentage points. In other words, there is a 1-to-2.03 link between the unemployment gap and the GNP gap.

3 This argument does not imply that productivity increases will be large at business cycle peaks and small at troughs because changes in productivity depend on labor's share, output, labor used, and the substitution between inputs. Whether the magnitude of productivity increase is small or large can not be determined given the available information

4 See Gordon [1987, pp. 317-319] for the analysis and graphical presentation of the relationship between the GNP gap and the unemployment rate. He defined the GNP gap as the ratio of actual real GNP to potential real GNP in percentage points. Another possible specification is (U/UN)=f(G) where UN is the natural unemployment rate. A regression was estimated. The findings are that the slope coefficient was significant at the 1% level and that the adjusted R-square was 0.987. However, the change in (U/UN) with respect to the change in G cannot be compared with the conventional specification because the fraction (U/UN) is different from U or (U-UN).

5 Seemingly autoregressive residuals may be due to serial correlation or an incorrect functional form or both. Savin and White [1978] was the first to point out this problem and tested for functional form and autocorrelation simultaneously.

6 The partial adjustment model can be specified as (Ut - Ut-1) = r(Ut* - Ut-1) + et where r is the adjustment coefficient, Ut* is the desired level of U, and e is the error term. The value of r is between 0 and 1. The greater the value of r, the faster the adjustment speed. See Kmenta [1986, pp. 528-532] for details.

7 For details on the Box-Cox transformation of variables, see Box-Cox [1964], Savin and White [1978], Seaks and Layson [1983], Smyth and Dua [1988], Spitzer [1982, 1984], and Zarembka [1974].

8 A simple linear regression without the lagged dependent variable and correction for autocorrelation was also estimated. An analysis of residuals found that Okun's law overpredicted changes in the unemployment rate at the peaks of business cycles.

9 Quarterly data for the Great Depression and World War II were not available.

10 Long-run values of dU_t/dG_t during these two periods are reported as follows:

Year and quarter	Long-run effect	Year and quarter	Long-run effect
1968.2	-0.293	1982.2	-0.710
1968.3	-0.286	1982.3	-0.749
1968.4	-0.282	1982.4	-0.801
1969.1	-0.280	1983.1	-0.782
1969.2	-0.282	1983.2	-0.754
1969.3	-0.296	1983.3	-0.706

11 Long-run effects in the 1970s were higher than those in the 1960s mainly because of the higher mean unemployment rate in the 1970s. According to Equation (2), when the unemployment rate is higher, the effect is also greater.

12 The natural unemployment rate of 5.6% was based on the estimate made by Gordon [1987].

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