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Okun's Law and Labor-Market Rigidity: The Case of Sweden

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Abstract

This paper proposes an extension of Okun's Law to allow for the potentially detrimental effects of labor-market rigidity on macroeconomic efficiency. The paper presents an econometric assessment of the law based on Swedish data for the years 1960-1995, showing that Okun's 3 to 1 relationship between the output gap and unemployment seems also to fit the Swedish situation during this period quite well. Nevertheless, labor-market regulation and rigidity inherited from the 1970s may have become a binding constraint on efficiency in the 1990s, when the Swedish economy took a deep dive, thus increasing unemployment well beyond the prediction of Okun's Law in its original form.

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In the early months of the Kennedy Administration, at the beginning of the 1960s, the Council of Economic Advisers in Washington, D.C., asked Arthur Okun to estimate the gains of gross national product (GNP) associated with a reduction of unemployment in the United States from 7 per cent to 4 per cent of the labor force. This led to Okun's (1962) justly famous discovery that a 3 per cent reduction in GNP was associated with an increase in unemployment of about 1 per cent in the United States.

This was an intriguing finding, because it implied that a reduction in unemployment had a much larger than proportionate effect on output, and must, therefore, according to Okun (1962), "stem from some or all of the following: induced increases in the size of the labor force; longer average weekly hours; and greater productivity."

Twenty years later, James Tobin (1983) described Okun's Law as "one of the most reliable empirical regularities of macroeconomics."

This paper is intended, first, to derive Okun's Law from first principles and to extend it to allow for the potentially detrimental effects of labor-market rigidity on macroeconomic efficiency, and to compare the extended version with Okun's own formulation of his law; second, to present an econometric assessment of the law based on Swedish data for the years 1960-1995, showing that Okun's 3 to 1 relationship seems also to fit the Swedish situation during this period; third, to show that Okun's Law leaves unexplained a significant part of the increase in unemployment in Sweden in the first half of the 1990s; and fourth, to suggest that labor-market regulation and rigidity inherited from the 1970s became a binding constraint on macroeconomic efficiency in the 1990s, when the Swedish economy took a deep dive, thus increasing unemployment well beyond the prediction of Okun's Law in its original form. Hence the proposed elaboration.

If the hypothesis that labor-market rigidity became a binding constraint on economic activity in the 1990s is correct, not only would restoring economic growth without closing the gap between potential and actual output not be enough to eradicate the unemployment problem in Sweden, but even closing the gap would not do either to restore full employment reasonably quickly, unless the macroeconomic stimulus required to close the gap were accompanied by significant deregulation and liberalization of the labor market. In other words, a lasting reduction of unemployment requires not only more growth, but also more flexibility in labor-market arrangements and institutions.

I. Okun's Law: An Extension

Okun's Law can be derived from production theory as follows.

Let potential output Y* be produced by labor and capital at full employment, L* and K*, through a Cobb-Douglas production function:

(1) $$Y^* = E^* L^{*a} K^{*1-a}$$

E* represents full efficiency and a and 1-a are the output elasticities, and national-income shares, of labor and capital.

Let actual output Y similarly be produced by labor and capital, L and K:

(2) $$Y = EL^a K^{1-a}$$

where E is actual efficiency.

The output gap g is defined as

(3) $$g = \frac{Y^* - Y}{Y^*}$$

Now let actual efficiency be proportional to full efficiency:

(4) $$E = \left[1 - ar\left(u - u_{-1}\right)\right]E^*$$

where r is a nonnegative parameter that reflects labor-market rigidity and u_{-1} is last year's unemployment rate. When labor markets are rigid (r > 0) and unemployment is on the rise ($u > u_{-1}$), the prevailing rigidity becomes a binding constraint, and begins to reduce efficiency below E*. For example, real wage rigidity compels firms to cut jobs rather than wages, even if the latter might be a more profitable reaction to reduced sales. Rigid hiring and firing rules, such as "last in, first out," are also inefficient, for they may force firms to discharge workers who are more productive than some of those who get to retain their jobs through seniority.

Equations (2) and (4) imply that the marginal and average products of both labor and capital vary directly with efficiency and, hence, inversely with rigidity, when unemployment is on the rise. When unemployment is falling ($u < u_{-1}$), rigidity tends to slow down the process by bringing E temporarily above E* and thus reducing the demand for labor. Rising unemployment entails no such inefficiency in a flexible labor market (with r = 0), because firms and workers are then free to adjust wages rather than jobs and to base hiring and firing decisions on efficiency, nor does rigidity harm efficiency in long-run equilibrium (where $u = u_{-1}$), because firms and workers then do not face the choice between lower wages and fewer jobs.

Let employment be proportional to the labor force:

(5) $$L = (1 - u + u^*)L^*$$

where u and u* are the actual and natural rates of unemployment.

Let the rate of utilization of capital be logarithmically proportional to the rate of capacity utilization in production in general:

(6) $$\frac{K}{K^*} = \left(\frac{Y}{Y^*}\right)^c$$

where c is a nonnegative constant. An increase in actual output towards potential output brings also the capital stock closer to its full-capacity level.

Actual output can now be expressed as

(7) $$Y = \left[1 - ar\left(u - u_{-1}\right)\right]\left(1 - u + u^*\right)^a \left[\left(\frac{Y}{Y^*}\right)^c\right]^{1-a} Y^*$$

Taking logarithms on both sides of equation (7), rearranging, and using the approximation ln(1-x) ≅ -x for small x, we get

(8) $$\left[1 - c(1-a)\right]\ln\left(\frac{Y}{Y^*}\right) \cong -a\left(u - u^*\right) - ar\left(u - u_{-1}\right)$$

By solving equation (8) for the unemployment rate, we obtain

(9) $$u \cong u^* - b\ln\left(\frac{Y}{Y^*}\right) - r\left(u - u_{-1}\right)$$

where

(10) $$b = \frac{1 - c(1-a)}{a}$$

At last, by approximating ln(Y/Y*) by -g, we can rewrite equation (9) as follows:

(11) $$u \cong u^* + bg - r\left(u - u_{-1}\right)$$

This is Okun's Law, disregarding the last right-hand-side term, which vanishes if unemployment is in long-run equilibrium ($u = u_{-1}$) or if labor markets are flexible (r = 0). If so, Okun's Law states that a shortfall of actual output by 1 per cent below potential output is associated with an increase in unemployment by approximately b per cent above the natural rate. If, for example, a = 0.75 and c = 3, then b = 1/3, as in Okun (1962). Alternatively, if a = 0.67 and c = 2.33, then, again, b = 1/3.

By solving equation (11) for u, we can rewrite Okun's Law as follows

(12) $$u \cong \frac{1}{1+r}u^* + \frac{r}{1+r}u_{-1} + \frac{b}{1+r}g$$

Now we see that labor-market rigidity has two distinct effects. First, if last year's unemployment exceeded the natural rate and the output gap is closed, then this year's unemployment still exceeds the natural rate in the presence of rigidity. Unemployment will then approach the natural rate from above, at a speed that is inversely related to rigidity: r/(1+r) is a measure of persistence. The solution to the first-order difference equation (12) is

(12') $$u_t = u_0\left(\frac{r}{1+r}\right)^t + \left(u^* + bg\right)\left[1 - \left(\frac{r}{1+r}\right)^t\right]$$

where u_0 is initial unemployment. In the extreme case where r tends to infinity, u equals u_0, an extreme form of hysteresis. Second, in the short run unemployment is less responsive to the output gap in the presence of rigidity (r > 0), and approaches the long-run equilibrium more slowly.

Past studies of Okun's Law have disregarded labor-market rigidity [see, for example, Prachowny (1993) and Nourzad and Almaghrbi (1995)]. Also, they have usually disregarded the interaction between labor and capital in production [Prachowny (1993) is an exception, however]. The latter practice is equivalent to setting c = 0 in equation (6), so that Okun's coefficient b then equals 1/a by equation (10). This, in turn, requires an implausible output elasticity of labor, equal to 3, for Okun's estimate b = 1/3 to be valid, *ceteris paribus*. Therefore, capital is included above.

Prachowny (1993) takes a different approach. He regresses the output gap in the United States on the gaps between (a) potential and actual utilization of capital; (b) potential and actual supply of labor; (c) natural and actual unemployment; and (d) potential and actual hours of work. He writes that "capacity utilization and weekly hours, but not the supply of workers, move independently enough of the unemployment rate to have measurable and significant effects on the output gap." He reports an output elasticity of labor of about 2/3, which means that an increase in unemployment by one percentage point increases the output gap by about 0.7 per cent, *ceteris paribus*. However, a simultaneous one-point increase in unemployment *and* a 3 per cent reduction in hours increase the output gap by about 3 per cent, *ceteris paribus*, as in Okun (1962). Prachowny's estimate of the output elasticity of capital is not significantly different from unity, implying constant returns to capital and increasing returns to scale. In this paper, by contrast, we assume constant returns to scale, see equation (1).

A special case. If the rate of capacity utilization is the same in the markets for labor and capital, we have, from equations (5) and (6),

(13) $$1 - u + u^* = \left(\frac{Y}{Y^*}\right)^c$$

It then follows from equation (7) that

(14) $$Y = \left[1 - ar\left(u - u_{-1}\right)\right]\left(1 - u + u^*\right)Y^*$$

so that

$$(15) \qquad u \cong \frac{1}{1+ar}u^* + \frac{ar}{1+ar}u_{-1} + \frac{1}{1+ar}g$$

If r = 0 or u = u_{-1}, equation (15) simplifies to

$$(16) \qquad u \cong u^* + g$$

In this case, a decrease in output of 1 per cent below potential is associated with an increase in joblessness by about 1 per cent above the natural rate. The relationship of output to unemployment then is 1 to 1 rather than 3 to 1.

An endogenous natural rate. Suppose the natural rate of unemployment u* responds to the recent behavior of actual unemployment according to

$$(17) \qquad u^* = v + mu_{-1} + qu_{-2}$$

where v, m, and q are constant coefficients. The substitution of equation (17) into equation (11) yields

$$(18) \qquad u = \frac{v}{1+r} + \frac{b}{1+r}g + \left(\frac{m+r}{1+r}\right)u_{-1} + \frac{q}{1+r}u_{-2}$$

The second-order difference equation (18) entails extreme hysteresis (a) if r is infinitely large, so that unemployment follows a random walk, or (b) if m+r+q = 0, in which case m $\leq$ 1 is necessary to avoid explosive fluctuations in the unemployment rate. If, on the other hand, m+r+q > 0 and q < 0, the model implies persistence, i.e., gradual adjustment of unemployment towards the long-run equilibrium value, u = (v+bg)/(1-m-q). In this case, unemployment overshoots its long-run equilibrium value in the short run if $(m+r)^2 < -4q(1+r)$. A more elaborate lag structure in equation (17) would complicate the lags in equation (18). The case of a constant natural rate, with m = q = 0 and v = u* in equation (17), reduces equation (18) to equation (12).

II. Okun's Own Formulation in Brief

Okun (1962) himself did not derive his law explicitly from an underlying production function. His approach was *ad hoc*. He approached his 3 to 1 relationship from three directions.

First, he fitted 55 quarterly observations for the United States economy from 1947:Q2 to 1960:Q4 to a simple equation, which yielded:

(19) $$\Delta u = 0.30 - 0.30\frac{\Delta Y}{Y} \qquad r = 0.79$$

where r is the correlation coefficient. He concluded that, without economic growth, unemployment would rise by 0.3 points from one quarter to the next, and that 1 per cent growth per quarter, or roughly 4 per cent growth per year, was required to keep unemployment unchanged. No confidence intervals or diagnostic test statistics were reported.

Second, Okun estimated the following regression with quarterly data for 1953-1960:[1]

(20) $$u = 3.72 + 0.36g \qquad r = 0.93$$

The gap g between potential and actual output was derived from a 3½ per cent trend line through actual GNP in mid-1955. Equation (20) "implies that an increment of unemployment of 1 per cent is associated with an output loss equal to 2.8 per cent of potential output—or a somewhat larger percentage of *actual* output when actual is below potential. The estimated unemployment rate associated with a zero gap is 3.72 percent, not too far from the 4.0 percent ideal." (Okun, 1962).

Third, Okun postulated that

(21) $$\frac{100-u}{96} = \left(\frac{Y}{Y^*}\right)^h$$

Fitted to various sample periods, the estimated output elasticity of the employment rate, h, was in the range from 0.35 to 0.40, "suggesting that each one percentage point reduction in unemployment means slightly less than a 3 percent increment in output (near the potential level). The trend growth rate, fitted to 1947-60 quarterly data, was 3.9 percent, but it was clear that it was not uniform throughout the period." (Okun, 1962).

[1] This equation was reported in the March 1961 statement of the Council of Economic Advisers to the Joint Economic Committee of the United States Congress.

It was on these three experiments that Okun based his 3 to 1 link between output and unemployment. His own subjectively weighted average of the relevant coefficients was 3.2, yielding his equation

$$(22) \qquad \frac{Y^* - Y}{Y} = 0.032(u - 4)$$

which implies, in our notation, that

$$(23) \qquad u = 4 + 0.31\left(\frac{100g}{1 - g}\right)$$

In equations (22) and (23), the output gap is measured relative to actual output (hence the division by 1-g on the right-hand side of equation (23)), whereas in equations (11) and (12) above it is measured relative to potential output.

III. Regression Estimates for Sweden

In order to assess the responsiveness of unemployment to changes in the output gap in Sweden, we now proceed to estimate the extended form of Okun's Law presented in equations (11) to (12) and (17) to (18).[2] This is done in two steps.

First, in order to estimate potential output in Sweden from 1960 to 1995, the natural logarithm of output is regressed on a time trend separately for the years 1960-1970 and 1971-1990, to allow for a possible break in the trend around 1970. This gives

(24) ln(Y) = -70.7 + 0.043 time $\qquad R^2 = 0.99$, DW = 0.88, N = 11, 1960-1970
(24.5) (29.2)

(25) ln(Y) = -23.4 + 0.019 time $\qquad R^2 = 0.99$, DW = 0.64, N = 20, 1971-1990
(17.8) (28.5)

where t-statistics are shown within parentheses.

The predicted values from these two regressions are then used to define potential output for 1960-1995, as shown by the light curve comprising two exponential segments in Figure 1. The natural logarithm of potential output is thus assumed to follow a piecemeal linear path.[3] The regressions confirm a marked slowdown of trend growth, from 4.3 per cent per year in the 1960s to 1.9 per cent per year in the 1970s and 1980s. The structural break in 1970 is statistically significant in a Chow test [F(2,27) = 127.1 with p = 0.00].[4] Figure 1 also shows actual output (the dark curve), which followed potential output fairly closely, with only minor deviations, from 1960 to 1990.

Second, we study the data on unemployment and the output gap from the years 1960-1995. Figure 2 shows open unemployment and the output gap, and Figure 3, total unemployment and the output gap. Open unemployment is defined in accordance with the standardized OECD definition. Total unemployment adds workers who hold jobs outside the regular labor market, through government-financed employment and education schemes, for instance. In both cases, a positive correlation between unemployment and the output gap is clearly visible, especially in the 1990s, when actual output fell far below potential output and unemployment rose to levels not seen since the Great Depression.

To study these relationships more closely, we now regress unemployment on the output gap, as defined in equation (3), measured in per cent, as well as on lagged values of unemployment in an attempt to capture the dynamics involved, including persistence or perhaps even hysteresis. At first, the data span the period from 1960 to 1990. This gives

$$(26) \quad u^{OPEN} = \underset{(3.5)}{0.83} + \underset{(2.2)}{0.08}\, g + \underset{(9.4)}{1.25}\, u_{-1} - \underset{(4.1)}{0.59}\, u_{-2} \qquad R^2 = 0.84,\ N = 29,\ F(4,21) = 4.0\ (p = 0.01)$$

$$(27) \quad u^{TOTAL} = \underset{(3.9)}{1.41} + \underset{(3.5)}{0.19}\, g + \underset{(8.2)}{1.10}\, u_{-1} - \underset{(3.4)}{0.46}\, u_{-2} \qquad R^2 = 0.83,\ N = 29,\ F(4,21) = 3.4\ (p = 0.03)$$

where N is the number of annual observations.

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[2] Data on output were obtained from Statistics Sweden, and data on unemployment were obtained from the Swedish National Labor Market Board. They are available on request from the author.

[3] Another possibility would be to assume that the first differences of the natural logarithm of output are white noise (i.e., that output follows a random walk, possibly with drift) or that the second differences are white noise. In either case, the *ex post* estimates of potential output through a Kalman-filter smoother or through a Hodrick-Prescott-filter smoother are in general qualitatively similar to a piecemeal linear pattern. See Tómasson (1991).

[4] On the other hand, the hypothesis that no structural change took place in 1980, around the time of the second oil price shock, cannot be rejected at the 0.05 level in a Chow test [F(2,27) = 3.6 with p = 0.051].

Test results. In both cases, the hypothesis of no structural change in 1970 can be rejected at the 0.05 level in a Chow test, as indicated by the F- and p-values following each regression. On the other hand, the hypothesis of no structural change in 1980 cannot be rejected [F(4,21) = 1.1 (p = 0.38) and F(4,21) = 1.6 (p = 0.22), respectively].

The hypothesis of no autocorrelation cannot be rejected in a Breusch-Godfrey Lagrange-Multiplier test [$\chi^2(2) = 0.26$ (p = 0.88) in equation (26) and $\chi^2(2) = 0.36$ (p = 0.83) in equation (27)].

The hypothesis of no heteroscedasticity cannot be rejected in a White test [$\chi^2(6) = 8.8$ (p = 0.19) and $\chi^2(6) = 8.1$ (p = 0.23) in the two equations]; see White (1980).

In a Ramsey RESET test, the hypothesis of no misspecification of the functional form cannot be rejected in either equation [$\chi^2(1) = 0.01$ (p = 0.91) and $\chi^2(1) = 0.96$ (p = 0.32), respectively]. Adding more lagged variables, such as g_{-1} or u_{-3}, to the list of independent variables does not significantly improve the regressions by the Wald test.[5] The lag specification is thus consistent with equation (18).

The hypothesis of no unit roots in the three series, u^{OPEN}, u^{TOTAL}, and g, in the sample period cannot be rejected in an Augmented Dickey-Fuller test at the 0.05 level. (The ADF t-statistics are -3.9, -3.6, and -3.7, respectively, with an intercept and a one-period lag.)

The statistical significance of the lagged dependent variables in equations (26) and (27) indicates persistence in unemployment, which may reflect labor-market rigidity, as in equations (12), (17), and (18), or other factors. Recursive Ordinary-Least-Squares (OLS) estimation did not display a trend in the constant term (or in other coefficients). This may be viewed as an indication that the natural rate of unemployment did not increase from 1960 to 1990.

The hypothesis of hysteresis (i.e., that the sum of the coefficients next to the lagged dependent variables in equations (26) and (27) is zero) is rejected in Wald tests [$\chi^2(1) = 56.0$ (p = 0.00) and $\chi^2(1) = 53.6$ (p = 0.00) in the two equations]. On the other hand, the hypothesis of no overshooting (i.e., that the square of the coefficient of u_{-1}

[5] The Wald test of the hypothesis that the inclusion of g_{-1} in equation (26) does not increase the explanatory power of the regression gives $\chi^2(1) = 4.3$ (p = 0.04), but the corresponding F-test gives F(1,24) = 3.9 (with p = 0.06), so that the Wald test is inconclusive at the 0.05 level. The corresponding test statistics for equation (27) are $\chi^2(1) = 0.10$ (p = 0.75) and F(1,24) = 0.08 (p = 0.77), so that the null hypothesis cannot be rejected.

equals minus four times the coefficient of u_{-2}, implying that the unemployment rate does not overshoot its long-run equilibrium value in the short run) can be rejected at the 0.05 level in equation (26), but it cannot be rejected at the same significance level in equation (27). [The $\chi^2(1)$-values are 4.5 (p = 0.03) and 3.0 (p = 0.08) in the two equations]. This indicates that the open unemployment rate fluctuates out of equilibrium, whereas the total unemployment rate may or may not do so.

When equations (26) and (27) are re-estimated for the whole period 1960-1995, similar results emerge, except the gap coefficients increase considerably with the addition of the first half of the 1990s to the sample:

(26') $u^{OPEN} = 1.05 + 0.21\, g + 1.09\, u_{-1} - 0.49\, u_{-2}$ $\quad R^2 = 0.93, N = 34$
(4.0) (3.9) (4.8) (2.5) $\quad F(4,22) = 9.5\ (p = 0.00)$

(27') $u^{TOTAL} = 1.84 + 0.32\, g + 1.17\, u_{-1} - 0.61\, u_{-2}$ $\quad R^2 = 0.96, N = 34$
(6.8) (5.2) (8.5) (4.5) $\quad F(4,22) = 6.7\ (p = 0.00)$

These equations have similar statistical properties as equations (26) and (27), except the t-values reported in equation (26') needed to be corrected for heteroscedasticity. The Chow-values point to significant structural changes in 1970 and 1990.[6] Wald tests indicate significant overshooting in both equations [the $\chi^2(1)$-values are 11.0 (p = 0.00) and 14.2 (p = 0.00) in the two equations]. Recursive OLS estimation shows an upward trend in the gap coefficients over the longer period that includes the first half of the 1990s, but not in the other coefficients, including the constant terms. These results appear to indicate that the dramatic increase in joblessness in Sweden in the 1990s reflects a combination of structural and cyclical factors.

When equations (26) and (27) are re-estimated for the years 1970-1990, in view of the significant trend breaks in 1970 and 1990, the following results obtain:

(26") $u^{OPEN} = 1.13 + 0.20\, g + 0.78\, u_{-1} - 0.25\, u_{-2}$ $\quad R^2 = 0.91, N = 21$
(5.8) (5.2) (5.5) (1.8) $\quad F(4,13) = 1.2\ (p = 0.35)$

(27") $u^{TOTAL} = 1.93 + 0.29\, g + 0.90\, u_{-1} - 0.36\, u_{-2}$ $\quad R^2 = 0.90, N = 21$
(5.6) (5.5) (7.0) (2.8) $\quad F(4,13) = 0.6\ (p = 0.67)$

[6] The hypothesis of no structural change in 1970, 1980, or 1990 cannot be rejected either in Chow tests [F(4,18) = 6.3 (p = 0.00) and F(4,18) = 4.2 (p = 0.00), respectively]. Ideally, sequential testing would be required to monitor structural change in the 1990s. See Chu, Stinchcombe, and White (1996).

Like equations (26') and (27'), these equations indicate a larger short-run response of unemployment to changes in the output gap than equations (26) and (27). This indicates that the relatively larger deviations of actual output from potential output in the 1970s and 1980s than in the 1960s (see Figure 1) may have increased the sensitivity of unemployment to the output gap. The hypothesis of no structural change in 1980 cannot be rejected in Chow tests, as shown by the F- and p-values following each regression. The hypotheses of no autocorrelation, no heteroscedasticity, no misspecification, and no omitted variables cannot be rejected either in Breusch-Godfrey, White, Ramsey, and Wald tests as before. Recursive estimation indicates that the coefficients are stable. The hypothesis of hysteresis is rejected by both equations as before. [The $\chi^2(1)$-values are 47.5 (p = 0.00) and 44.8 (p = 0.00) in the two equations]. Moreover, the hypothesis of no overshooting cannot now be rejected at the 0.05 level in either case [the $\chi^2(1)$-values are 0.9 (p = 0.33) and 3.2 (p = 0.07), respectively].

The long-run relationships between unemployment and the output gap implied by equations (26) to (27") are found by setting $u = u_{-1} = u_{-2}$ and then solving for u. This gives

(28) $u^{OPEN} = 2.44 + 0.24\ g$ (1960-1990)

(29) $u^{TOTAL} = 3.92 + 0.53\ g$ (1960-1990)

(28') $u^{OPEN} = 2.62 + 0.50\ g$ (1960-1995)

(29') $u^{TOTAL} = 4.18 + 0.73\ g$ (1960-1995)

(28") $u^{OPEN} = 2.40 + 0.43\ g$ (1970-1990)

(29") $u^{TOTAL} = 4.26 + 0.64\ g$ (1970-1990)

These equations, like Okun's [see equation (20)], can be interpreted as follows. Assuming that labor-market rigidity was not binding during the full-employment period 1960-1990, the open unemployment rate in Sweden was about 2.4 per cent of the labor force on average, while the total unemployment rate was about 3.9 per cent on average. When actual output decreased by 4 per cent below potential output within the sample range, open unemployment increased by about 1 per cent above the natural rate in the long run, and total unemployment rose by about 2 per cent above the natural rate in the long run. Equations (28') to (29") can be given a similar interpretation.

When equations (28) to (29") are estimated directly from the data, as Okun (1962) did, i.e., without dealing with the dynamics involved through the lagged dependent variables in the underlying equations (26) to (27"), we get

(30) $u^{OPEN} = \underset{(20.6)}{2.49} + \underset{(1.7)}{0.13}\, g$ $R^2 = 0.09$, DW = 0.41, N = 31, 1960-1990

(31) $u^{TOTAL} = \underset{(23.1)}{3.90} + \underset{(2.2)}{0.24}\, g$ $R^2 = 0.15$, DW = 0.50, N = 31, 1960-1990

(30') $u^{OPEN} = \underset{(16.1)}{2.59} + \underset{(9.2)}{0.51}\, g$ $R^2 = 0.72$, DW = 0.56, N = 36, 1960-1995

(31') $u^{TOTAL} = \underset{(16.9)}{4.06} + \underset{(10.2)}{0.84}\, g$ $R^2 = 0.75$, DW = 0.69, N = 36, 1960-1995

(30") $u^{OPEN} = \underset{(25.7)}{2.44} + \underset{(5.3)}{0.32}\, g$ $R^2 = 0.60$, DW = 0.74, N = 21, 1970-1990

(31") $u^{TOTAL} = \underset{(25.3)}{4.18} + \underset{(4.5)}{0.46}\, g$ $R^2 = 0.51$, DW = 0.97, N = 21, 1970-1990

The autocorrelation indicated by the low Durbin-Watson statistics in these equations undermines the interpretation of the standard errors of the regression coefficients. Nevertheless, the estimates of the natural rate of unemployment are similar in the two groups of equations, (28) to (29") and (30) to (31"), but the sensitivity of unemployment to the output gap appears smaller—and is less precisely estimated, as expected, especially in equation (30)—when the lagged dependent variables are left out of the estimation. The presence of the lagged dependent variables in equations (26) to (27") eliminates the autocorrelation according to the Breusch-Godfrey test.

Alternative estimates. In the derivation of the estimating equation (18), unemployment was treated as the dependent variable, following Okun (1962). Equation (18) can also be expressed in terms of the output gap as a function of u, u_{-1}, and u_{-2} as follows:

(18') $$g = -\frac{v}{b} + \left(\frac{1+r}{b}\right)u - \left(\frac{m+r}{b}\right)u_{-1} - \left(\frac{q}{b}\right)u_{-2}$$

The equation fits the data less well in this inverted form. The coefficients of the lagged dependent variables cease to be statistically significant, and both change signs in the equation for total unemployment (not shown). When the second lagged dependent variable is left out, so that q = 0 in equations (17), (18), and (18'), then these regressions obtain for the period 1960-1995:

(32) $g = -3.09 + 2.00\, u^{OPEN} - 0.75\, u_{-1}$ $R^2 = 0.76$, DW = 0.69, N = 35
(5.9) (6.4) (2.1) F(3,29) = 12.3 (p = 0.00)

(33) $g = -3.28 + 1.33\, u^{TOTAL} - 0.51\, u_{-1}$ $R^2 = 0.82$, DW = 0.93, N = 35
(7.2) (7.4) (2.5) F(3,29) = 5.9 (p = 0.00)

The hypothesis of no autocorrelation can now be rejected as indicated by the low Durbin-Watson statistics [the $\chi^2(2)$-values are 18.5 (p = 0.00) and 12.7 (p = 0.00), respectively, in a Breusch-Godfrey Lagrange-Multiplier test]. The autocorrelation undermines the interpretation of the standard errors of the regression coefficients. The hypothesis of no heteroscedasticity cannot be rejected [the $\chi^2(4)$-values are 4.1 (p = 0.39) and 4.0 (p = 0.41) in a White test]. The sum of the coefficients next to u and u_{-1} is significantly different from zero in both equations, so that the hypothesis that m = 1 can be rejected at the 0.05 level in a Wald test [the $\chi^2(1)$-values are 60.7 (p = 0.00) and 88.2 (p = 0.00), respectively]. Extreme hysteresis is thus rejected in favor of persistence as before. The absence of u_{-2} from the equations precludes overshooting. Chow's F-statistics indicate structural changes in 1970 and 1990 as before.

The long-run relationships between unemployment and the output gap implied by equations (32) and (33) are found by setting $u = u_{-1}$ and then solving for u. This gives

(34) $u^{OPEN} = 2.47 + 0.80\, g$ (1960-1995)

(35) $u^{TOTAL} = 4.00 + 1.22\, g$ (1960-1995)

where the coefficients next to g are reduced-form estimates of b/(1-m); see equation (18'). Hence, if m = 0.25, say, then b equals 0.60 and 0.92 in the two equations, respectively, and the corresponding values of r are 0.20 and 0.22. These equations indicate similar natural rates of unemployment as before [see equations (28') and (29')], but considerably less sensitivity of the output gap to unemployment. However, because of their weak statistical properties, equations (32) to (35) need to be taken with a grain of salt.

Numerical examples. Equations (17) to (18) offer a possible interpretation of the coefficients of the lagged dependent variables in the estimating equations (26) to (27") in terms of an endogenous natural rate that reacts to past unemployment. A comparison of the estimating equations with equation (18) shows that they are underdetermined. Hence, one of the five structural coefficients (b, r, m, q, and v) must be obtained elsewhere in order to make it possible to assess the remaining four.

For example, let b be 1/3 in the open unemployment equation (26"), as in Okun (1962). Then r = 0.67, m = 0.63, q = -0.42, and v = 1.89; and if c = 3, then a = 0.75 [see equations (2) and (6)]. The implicit natural rate of open unemployment in 1995, given the actual rates of 1993 and 1994 (see Table 1), is then 3.5 per cent by equation (17), but it fluctuates over time, falling below 1 per cent before settling at 2.4 per cent, as in equation (28"), after about nine years.

For another example, let b be 0.5 in the total unemployment equation (27"), as in Gordon (1984) and Clark (1984). Then r = 0.72, m = 0.83, q = -0.62, and v = 3.32; and if c = 3, then a = 0.8. The implicit natural rate of total unemployment in 1995, given the actual rates of 1993 and 1994 (see again Table 1), is then 6.5 per cent by equation (17), but it fluctuates considerably before settling at 4.3 per cent, as in equation (29"), after about 20 years.

To take one more example, let r be zero in a fully flexible labor market. Then b = 0.20, m = 0.78, q = -0.25, and v = 1.13 by equation (26") and b = 0.29, m = 0.90, q = -0.36, and v = 1.93 by equation (27"). The implicit natural rates of open and total unemployment in 1995 are now 5.3 per cent and 9.3 per cent. In this case, the natural rate is about 2 to 3 points higher than before, because labor-market rigidity has been assumed away.

Equations (26) to (27') can be interpreted in a similar way.

Prediction and decomposition. Table 1 shows the actual and predicted values of open and total unemployment, when the regression equations for 1960-1990 are extrapolated to the years 1991-1995 to generate predictions *ex ante* and also, for comparison, when the regression equations for 1960-1995 are used to predict unemployment in 1991-1995 *ex post*. The equations for 1960-1990 correctly predict a substantial increase in unemployment resulting from the shortfall of output in 1991-1995, but still they underestimate the actual increase in unemployment by 1 to 6 percentage points during this period. Specifically, they underestimate the open unemployment rate by 2.5 per cent a year on average, and the total unemployment rate, by 3.8 per cent a year on average. Based on the equations for 1960-1990, the widening output gap explains only between 60 per cent and 80 per cent of the increase in joblessness in the 1990s. The equations for the whole sample period, 1960-1995, provide more accurate predictions of unemployment *ex post*. Yet, they underestimate the open unemployment rate by 0.3 per cent a year on average, and the total unemployment rate, by 0.5 per cent a year on average.

Table 1. Sweden: Open and Total Unemployment, Actual and Predicted, 1991-1995 (In Per Cent)

	u^{OPEN}			u^{TOTAL}		
	Actual	Predicted *ex ante*	Predicted *ex post*	Actual	Predicted *ex ante*	Predicted *ex post*
1991	2.9	2.1	2.5	4.8	3.5	3.9
1992	5.3	3.0	4.4	8.9	5.0	7.4
1993	8.2	4.1	7.2	12.7	7.0	12.1
1994	8.0	4.9	9.1	13.3	8.4	13.9
1995	7.7	5.2	7.2	12.1	8.9	11.9

Note: Predictions *ex ante* are based on equations (26) and (27) for 1960-1990.
Predictions *ex post* are based on equations (26') and (27') for 1960-1995.

Table 2. Sweden: Decomposition of Actual Unemployment in 1995 Based on Okun's Law (In Per Cent)

Panel A	u^{OPEN}			
	Actual	Natural	Cyclical	Residual
1960-1990	7.7	2.4	1.7	3.6
1960-1995	7.7	2.6	3.6	1.5
1970-1990	7.7	2.4	3.1	2.2
Panel B	u^{TOTAL}			
	Actual	Natural	Cyclical	Residual
1960-1990	12.1	3.9	3.8	4.4
1960-1995	12.1	4.2	5.3	2.6
1970-1990	12.1	4.3	4.6	3.2

Note: Estimates of natural and cyclical unemployment are based on equations (28) to (28") in Panel A and (29) to (29") in Panel B.

In Table 2 we divide actual unemployment in 1995 into three components, as in equations (11) and (12): (i) a natural component equal to the constant terms in long-run-equilibrium unemployment equations (28) to (29”); (ii) a cyclical component equal to the variable terms in those equations; and (iii) a residual component, which can be ascribed either to an increase in the natural rate of unemployment or to hitherto latent labor-market rigidity (and its interaction with short-run movements in unemployment), or both.

As before, the natural rates of open and total unemployment are close to 2½ per cent and 4 per cent or so, respectively, whether the sample period is 1960-1990, 1960-1995, or 1970-1990; see equations (28) to (29”). The total unemployment rate at full employment is slightly higher for the latter two periods, or 4.2 per cent to 4.3 per cent compared with 3.9 per cent. With the output gap prevailing in 1995 ($g = 7.24$), the cyclical rates of open and total unemployment range from 2 per cent to 5 per cent. On average, this renders between a third and a quarter of open and total unemployment, or 1½ to 4½ percentage points, unexplained by natural unemployment, as defined here, and the output gap, as shown in the last column of Table 2.

Interpretation. There are at least two, not necessarily incompatible, ways of interpreting the residuals displayed in the last column of Table 2. First, as, for example, in Phelps (1994, Chapter 17), the residuals may reflect a rise in natural unemployment in a wide sense, as a consequence of increased actual joblessness, see equation (17). If so, the natural rate of open unemployment in 1995 was somewhere between 4 per cent and 6 per cent, and the natural rate of total unemployment was in the neighborhood of 7 per cent to 8 per cent. These numbers appear implausibly high for a country where open and total unemployment hovered between 2 per cent and 4 per cent and between 3 per cent and 6 per cent, respectively, from 1960 until the early 1990s. Moreover, the stability of the constant terms in equations (26) to (27”) indicated by the results of the recursive estimation seem to undermine, or at least weaken, this interpretation.

The second interpretation is that the labor-market rigidity inherited from the 1970s[7] did not become a binding constraint on the hiring and firing decisions of Swedish employers until the economy took a deep dive in the 1990s. In the 1970s and

[7] Specifically, a new law on labor protection was passed in 1974, complicating lay-off procedures and thus indirectly discouraging job creation. See Gylfason, Andersen, Honkapohja, Isachsen, and Williamson (1997, Chapter 3).

1980s, the malfunctioning of the Swedish labor market tended to be overlooked, because the government acted as an employer of last resort by expanding public-sector employment when demand for labor in the private sector declined,[8] and also because the government devalued the krona more than once in an attempt to restore profitability to Swedish exports.[9] In the early 1990s, when further fiscal accommodation and further devaluation of the krona were no longer feasible, the previously latent labor-market inflexibility came out into the open. This inflexibility became an additional source of unemployment, on top of existing natural (or structural) and cyclical unemployment, forcing employers to lay off workers, because wages could not be reduced, and so on. The jump in unemployment in the 1990s should then not be blamed on the abruptly non-accommodating stance of public-expenditure and exchange-rate policy; rather, the root cause may be traced to the labor-market rigidity, which led to the ultimately unsustainable accommodation of the 1970s and 1980s in the first place.

The main implication of the foregoing is as follows. In order to restore full employment in a timely manner, the Swedish government must not only close the output gap by appropriate, non-inflationary stimulus to aggregate supply and demand, but it must also introduce legislation to secure increased flexibility in the structure and functioning of the labor market. Without such reform, the return to full employment, if it occurs, will be slower than otherwise, *ceteris paribus*.

Numerical simulations. To see this clearly in quantitative terms, suppose that $u^{OPEN} = 7.7$, as in 1995 (see Table 2); that $b = 0.33$, as in Okun (1962); and that the output gap remains unchanged at $g = 7.24$ over a number of years. Then u^{OPEN} will gradually fall from 7.7 per cent to 5.0 per cent, other things being equal, assuming an exogenous natural rate equal to the constant term in equation (28'), so that $u^{OPEN} = u^* + bg = 2.6 + 0.33*7.24 = 5.0$ in the long run by equation (12). This decrease in unemployment by almost three points will take two years if $r = 0.1$, three years if $r = 0.33$, five years if $r = 0.67$, six years if $r = 1$, and ten years if $r = 2$. The sensitivity of the speed of adjustment to the rigidity parameter r is thus considerable.

If, on the other hand, the natural rate is endogenous as in equation (17), u^{OPEN} gradually falls from 7.7 per cent in 1995 to 6.4 per cent, *ceteris paribus*, by equation

[8] From 1950 to 1990, public-sector employment in Sweden increased by more than 1 million, while employment in the private sector fell by about 100.000. See Henrekson (1996).

(26'); the process takes about 6 or 7 years. Similarly, by equation (27'), u^{TOTAL} falls from 12.1 per cent to 9.4 per cent, *ceteris paribus*, in about 14 years, fluctuating between 8 per cent and almost 10 per cent along the way.

Dynamic simulations of equations (26) to (27) and (26") to (27") yield similar results.

IV. Conclusion

In this paper an attempt has been made to map the relationship between actual and potential output and unemployment in Sweden since 1960. Okun's Law fits the Swedish data quite well. An increase by 1 per cent in the gap between potential and actual GNP in Sweden goes hand in hand with an increase in open unemployment by 0.2 per cent to 0.5 per cent, and with an increase in total unemployment by 0.5 per cent to 0.7 per cent. These numbers entail, approximately, a 3 to 1 relationship between the output gap and open unemployment, as in Okun's (1962) original work, and a 2 to 1 relationship between the output gap and total unemployment, which also appears to fit more recent data for the United States economy more accurately [see Gordon (1984) and Clark (1984)].

The emergence of an output gap of more than 7 per cent of potential output since the early 1990s has added a substantial and persistent cyclical component to unemployment in Sweden. The regression estimates indicate that this cyclical component amounts to about 2 per cent to 3 per cent extra open unemployment in the mid-1990s, and about 4 per cent to 5 per cent extra total unemployment. Even so, there remains a significant unexplained residual component of unemployment, equivalent in 1995 to between 1½ per cent and 4½ per cent of the labor force. This residual must reflect either an increase in the natural rate over time, as, for example, in Phelps (1994), or, perhaps more plausibly, the delayed consequences of ingrained labor-market rigidity, which became a binding constraint on efficiency and employment in the economic crisis of the 1990s. Whether the residual unemployment stemming from the latter phenomenon, if real, ought to be classified as an addition to natural unemployment or not is a matter of taste and terminology.

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[9] The Swedish krona was devalued in 1976-1977, 1981-1982, and 1992, each time by about 20 per cent or more.

The analysis offered in this paper is not conclusive: it is solely meant to suggest a potentially important additional source of increased unemployment in Sweden in the 1990s. Conclusive evidence on this subject would require a detailed qualitative and quantitative examination of specific types of rigidity in the Swedish labor market, and of their relationship to real wages, unemployment, and actual and potential output. In view of the structural similarities between labor-market arrangements and institutions in Sweden and in much of the rest of the European Union, the potential consequences of labor-market rigidity for unemployment are not solely a Swedish concern, but a European one.

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Figure 1. Sweden: Actual and Potential GDP, 1960-1995 (SEK Billion at 1991 Prices)

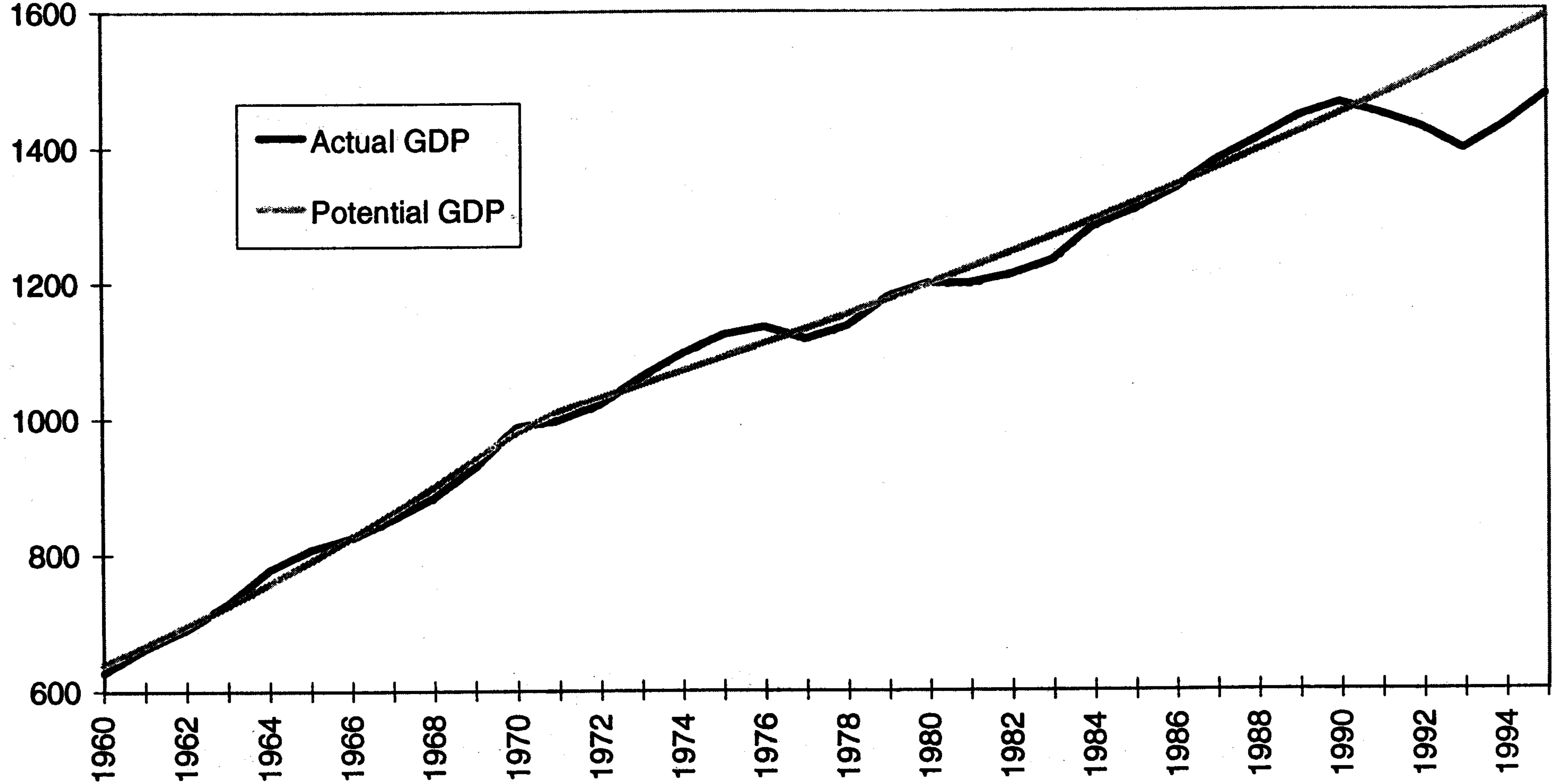

Figure 2. Sweden: Open Unemployment and the Output Gap, 1960-1995

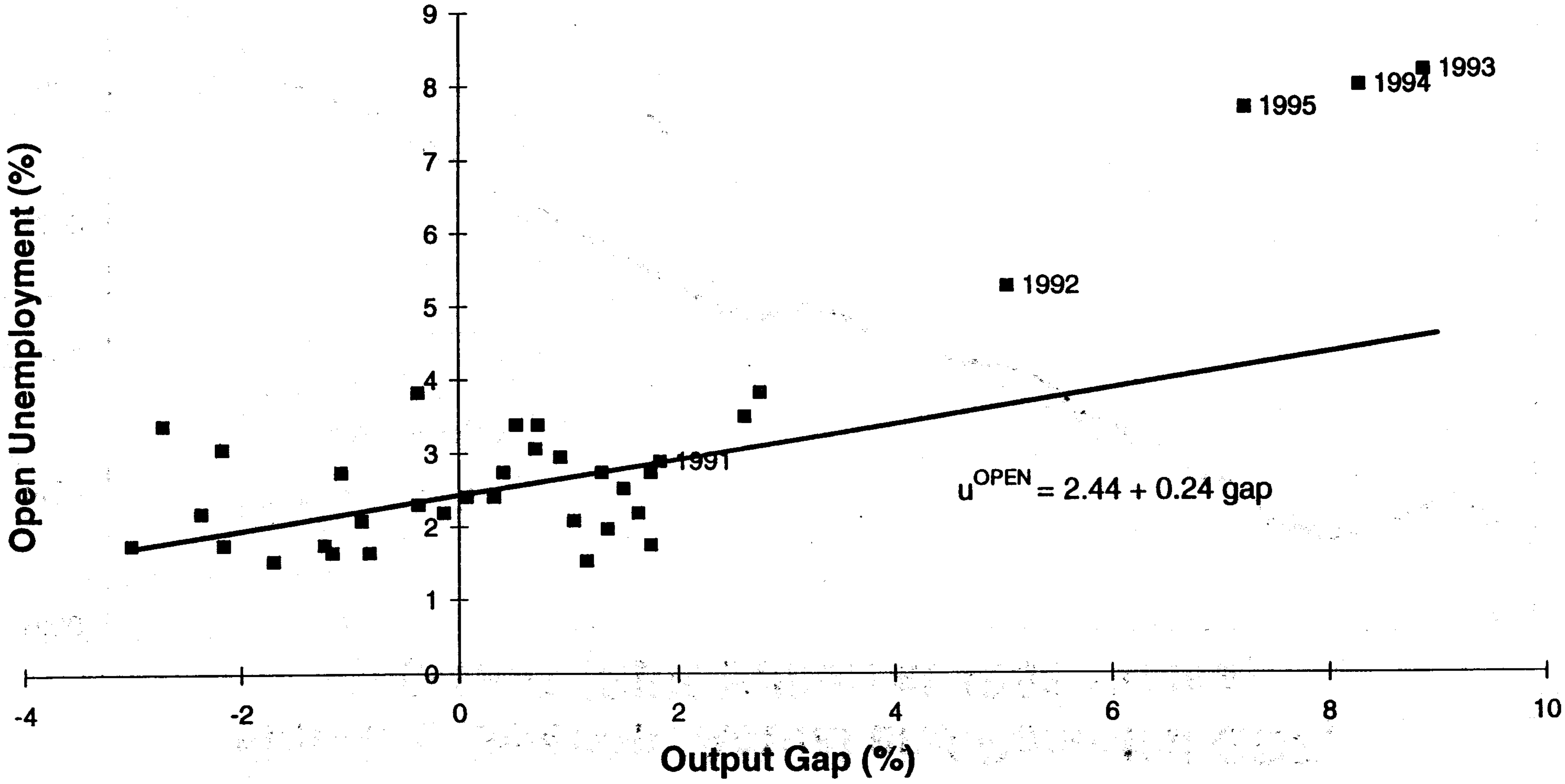

Figure 3. Sweden: Total Unemployment and the Output Gap, 1960-1995