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Estimating the Natural Rate of Unemployment for the United States

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I. Introduction

Toward the end of the 1960s, several economists including Milton Friedman developed the notion that there could be no lasting tradeoff between inflation and unemployment.1/ They argued that if price and wage inflation were correctly anticipated by firms and workers, the rate of unemployment would be determined by the underlying structure of the real economy rather than by the level of inflation. In this context, the natural rate of unemployment was viewed as that rate of unemployment that would prevail in the longer run when expectations about inflation were fulfilled.

The level of the natural rate of unemployment is an important input to policy analysis for various reasons. First, the gap between the natural and the actual unemployment rates provides an indicator of tightness in the labor market or, more generally, of demand pressures in the economy. Second, the natural rate can be viewed as a benchmark around which the actual unemployment rate fluctuates during the business cycle, and thus can be used as a basis for estimating the cyclical and structural components of such variables as the fiscal balance.2/ Inaccuracies in the estimation of the natural rate may therefore have serious consequences for macroeconomic policy. For example, an unnoticed increase in the natural rate may lead to the underestimation of the extent of demand pressures in the economy and of the size of the structural fiscal deficit, and could give rise to the pursuit of an excessively expansionary macroeconomic policy.

Two distinct approaches have been used to obtain econometric estimates of the natural rate of unemployment for the United States. The first approach identifies the natural rate of unemployment as that rate of unemployment at which the rate of price inflation would be constant;

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1/ See Milton Friedman, "The Role of Monetary Policy", American Economic Review, Vol. 58, pp. 1-17 (1968).

2/ See, for example, Budget of the United States Government: Fiscal Year 1985, Office of Management and Budget (1984).

this rate of unemployment may be inferred from the estimated coefficients of Phillips-curve price inflation equations. The second method relates the unemployment rate directly to various labor market and cyclical variables in a reduced-form equation. Estimates of the natural rate are derived by setting the values of the cyclical variables at their trend levels.

This paper surveys previous attempts to measure the natural rate of unemployment for the United States, and provides estimates of its value in recent years. Sections II and III of the paper discuss several studies based on the Phillips-curve approach and reduced-form approach, respectively. Section IV extends previous work using the reduced-form approach, seeking to (i) identify additional indicators of structural conditions in labor markets that may have a significant influence on the natural rate, (ii) determine the short-run impact, if any, of movements in aggregate demand other than those resulting from monetary shocks, and (iii) investigate the cause and extent of cyclical variation in the frictional component of unemployment. Section V uses the results obtained in Section IV to distinguish between shifts in the natural rate and cyclical fluctuations of unemployment. The section traces the path of the natural rate during the period 1954-83, and accounts for fluctuations around this path in terms of various cyclical factors. Finally, in Section VI, the consistency of this natural rate series with observed price behavior is checked by estimating a Phillips-curve equation using the deviation of the actual unemployment rate from the natural rate as the measure of labor market slack.

II. The Phillips-Curve Approach

Phillips-curve equations typically relate price or wage inflation to the rate of unemployment and other variables, including a distributed lag of actual price inflation as a proxy for the expected rate of price inflation. The natural rate of unemployment may be identified in this context as the "non-accelerating inflation rate of unemployment" (NAIRU), that is, the rate of unemployment at which the rate of price inflation is constant. In the framework of a model with adaptive price expectations, NAIRU is the appropriate definition for the natural rate, as adaptive price expectations can only be fulfilled consistently if the rate of price inflation does not change.

To illustrate how NAIRU may be estimated, consider the following simple model of price and wage setting behavior. Let the rate of increase of wages (w) be negatively related to the unemployment rate (U), positively related to the expected rate of price inflation (p^e) and a function of other variables that influence labor market conditions (Z_w):

$$w = a_o - a_1 U + a_2 Z_w + p^e \quad (1)$$

Expectations about price inflation in this model are assumed to be adaptive and can be expressed as a distributed lag of past rates of inflation:

$$p^e = \sum_i b_i \; p_{-i} \qquad (2)$$

where p is the actual rate of inflation. The restriction that the coefficients b_i sum to one is required to ensure that inflationary expectations would be satisfied if inflation were constant over time.

Prices are assumed to be determined as a mark-up over labor costs, where the mark-up may vary pro-cyclically. The rate of change of prices is therefore positively related to wage inflation, negatively related to the degree of slack in the economy, and also affected by other variables (Z_p) such as the rate of change of productivity. Using the unemployment rate as a proxy for the degree of slack, the price equation may be expressed:

$$p = w - c_1 \; U + c_2 \; Z_p \qquad (3)$$

Substituting equations (1) and (2) into (3) gives the reduced-form equation for price inflation:

$$p = a_0 + \sum_i b_i \; p_{-i} - (a_1 + c_1) \; U + a_2 \; Z_w + c_2 \; Z_p \qquad (4)$$

NAIRU may be obtained directly from equation (4) as the value of the unemployment rate at which the current inflation rate would equal its past values:

$$NAIRU = (a_0 + a_2 \; Z_w + c_2 \; Z_p)/(a_1 + c_1) \qquad (5)$$

Hence, according to equation (5), NAIRU depends on various factors that affect wage and price formation; for example a change in the rate of growth of productivity would alter NAIRU. Note that, to the extent that these explanatory variables change during the business cycle, the estimate of NAIRU based on (5) would also vary over the cycle. To obtain a cyclically adjusted value for NAIRU, trend rather than actual values of these variables should be inserted into equation (5).

1. Modigliani and Papademos 1/

One of the earliest attempts to derive NAIRU from estimates of Phillips-curve equations was due to Modigliani and Papademos. A typical equation in their study was:

$$p = a_0 + a_1 \; 1/UA + a_2 \; p_{-1} + a_3 \; q + a_4 \; p_m + a_5 \; p_{f-1} \qquad (6)$$

where:

1/ Franco Modigliani and Lucas Papademos, "Targets for Monetary Policy in the Coming Year", Brookings Papers on Economic Activity, 1975:1, pp. 141-165.

p = rate of change in the consumer price index excluding food,
UA = Perry-weighted unemployment rate,1/
q = rate of increase of output per hour in nonfarm business sector,
p_m = rate of change in import prices, and
p_f = rate of change in farm product prices.

Equation (6) and similar equations were estimated by Modigliani and Papademos using annual data over the period 1953-71. In these equations, the estimated coefficients on lagged inflation clustered around 0.8. Estimates of NAIRU were derived for the period as a whole from coefficient estimates by setting p and p_{-1} to 2 percent; setting q, p_m, and p_{f-1} to their average values; and by adding back the demographic adjustment factor.2/ These estimates ranged between 5.1 and 5.8, depending on the particular specification of equation (6) used. However, these values cannot be properly identified as natural rates because, in allowing the coefficient on lagged inflation to deviate from one, Modigliani and Papademos do not require price expectations to be satisfied in a situation of constant inflation. In the absence of such a restriction, different values of NAIRU would be consistent with different rates of inflation, which would violate the natural rate hypothesis.

2. Gordon 3/

Gordon's paper contained estimates of a series of equations for price inflation based on a model of price and wage formation similar to the one outlined above. The study used quarterly data over the period from the second quarter of 1954 to the fourth quarter of 1980. A typical equation was:

$$p = b_0 + \sum_i b_i \, p_{-i} + b_2 \, UA + b_3 \, \Delta UA + b_4 \, Z_w + b_5 \, Z_p + \sum_k b_k \, D_k \quad (7)$$

where the coefficients b_i were constrained to sum to one by a two-step estimation procedure described below. The dependent variable, p, was the rate of change of the GNP fixed-weight index and UA was the Perry-weighted unemployment rate. The vector Z_w included the ratio of the minimum wage to average weekly earnings and the ratio of total social

1/ The Perry-weighted unemployment rate is constructed as a weighted average of unemployment rates in each age-sex category, with the weights chosen to reflect the demographic composition of the labor force in the base year. See George L. Perry, "Changing Labor Markets and Inflation", Brookings Papers on Economic Activity, 1970:3, pp. 111-141.

2/ The demographic adjustment factor is obtained as the difference between the official rate of unemployment and the Perry-weighted rate of unemployment.

3/ Robert J. Gordon, "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment," in Martin Neil Baily, Workers, Jobs, and Inflation, Brookings Institution (1982).

security contributions to wages and salaries. The vector Z_p included the growth of output per hour in the nonfarm business sector relative to trend, changes in energy and food prices, movements of the effective exchange rate, a variable representing shifts in indirect tax rates, and dummy variables intended to represent the effects of the price controls imposed in the early 1970s. The D_k were dummy shift variables intended to represent other factors that might shift NAIRU over time; D_k was set equal to unity during the period k and to zero otherwise.

Gordon calculated the value of NAIRU for period k as $-(b_o + b_k)/b_2 + ADJ_k$, where ADJ_k is the average demographic adjustment factor in period k.1/ On the basis of a regression equation that included the complete set of Z_w and Z_p variables, he inferred that the value of NAIRU had shifted from just under 5 percent in the period 1954-59 to 5 1/2 percent in the 1960s and to 6 percent in the 1970s. This shift was due to the changing value of the demographic adjustment factor over time rather than to the influence of the dummy shift variables as the coefficients b_k were not significantly different from zero. Gordon drew the conclusion that "there has been no upward shift in the natural rate for other than demographic reasons."2/

Estimates based on Gordon's method that take account of recent data suggest that non-demographic as well as demographic factors may have affected the natural rate over the past five years or so. The following equation was estimated by ordinary least squares using quarterly data for the period from the first quarter of 1963 to the first quarter of 1983:

$$\begin{aligned} p = \; & \underset{(5.2)}{0.033} - \underset{(4.0)}{0.057}\, UA - \underset{(1.0)}{0.037}\, \Delta UA - \underset{(1.5)}{0.114}\, e \\ & + \underset{(1.5)}{0.563}\, f - \underset{(1.7)}{0.072}\, q - \underset{(2.2)}{0.056}\, D1 + \underset{(5.9)}{0.132}\, D2 \\ & + \underset{(3.3)}{0.011}\, D3 + \underset{(14.3)}{0.724} \sum_{i=1}^{8} a_i\, p_{-i} \end{aligned} \tag{8}$$

i	1	2	3	4	5	6	7	8
a_i	0.10	0.13	0.15	0.16	0.16	0.14	0.10	0.06

$\bar{R}^2 = 0.89$ $\qquad h = 0.41$ $\qquad SEE = 0.095$

1/ It should be noted that Gordon's measure of NAIRU is strictly correct only if all b_4 Z_w and b_5 Z_p in equation (7) are equal to zero in the long run. Otherwise, these terms should be included in the derivation of NAIRU. In Gordon's regression estimates, the coefficients on the variables included in Z_w were found to be insignificantly different from zero, so that the omission of the b_4 Z_w factors may be justified. Turning to the b_5 Z_p terms, the trend of the effective exchange rate was flat over Gordon's estimation period, but the relative prices of food and energy tended to increase. This would suggest some underestimation of NAIRU, but the magnitude of the error would be rather small.

2/ Gordon, op. cit. p. 111.

Figures in parentheses are t statistics. The dependent variable (p) is the rate of change of the GNP fixed-weight index.1/ The independent variables include all variables with significant coefficients in Gordon's preferred equation (equation 6 in his paper). UA is the Perry-weighted unemployment rate; e is the rate of change in the effective exchange rate of the U.S. dollar; f is the rate of change in food and energy prices relative to the zNP fixed-weight price index; q is the rate of change in output per hour in the non-farm business sector relative to trend; and D1 and D2 are dummy variables included to capture the effects of the price controls of the early 1970s.2/ D3 is a dummy shift variable included to represent other factors that might have altered the natural rate in the late 1970s and early 1980s relative to the 1960s.3/ The h-statistic is used to test for the presence of autocorrelation in a regression equation including lagged endogenous variables.

The sum of lagged coefficients on price inflation in equation (8) is only 0.72. In order to impose the constraint that coefficients on the lagged price inflation terms sum to one, a proxy for expected inflation was constructed in the manner suggested by Gordon.4/ Estimates of unexpected inflation (p^u) were then derived as the difference between actual inflation and expected inflation, and regressed on the independent variables appearing in equation (8):

$$\begin{aligned} p^u = \; & \underset{(5.0)}{0.026} - \underset{(4.3)}{0.006}\,UA - \underset{(1.8)}{0.006}\,\Delta UA - \underset{(2.9)}{0.193}\,e + \underset{(5.3)}{0.601}\,f \\ & - \underset{(1.6)}{0.069}\,q - \underset{(1.5)}{0.038}\,D1 + \underset{(6.3)}{0.119}\,D2 + \underset{(2.2)}{0.007}\,D3 \end{aligned} \tag{9}$$

$\overline{R}^2 = 0.72 \qquad DW = 1.97 \qquad SEE = 0.010$

The coefficient of the shift dummy for 1977-83 in equation (9) is significantly positive, which suggests that an upward shift of NAIRU did take place for other than demographic reasons. On the basis of equation (9), NAIRU is estimated to have risen from around 6 percent in the 1960s to just over 7 percent in the late 1970s and early 1980s;

1/ All rates of change are expressed as the first difference of the logarithm of the variable, and are represented by lower case symbols.

2/ For precise specification of e, f, q, D1 and D2, see Gordon, op. cit.

3/ D3 is set to unity for the period from the first quarter 1977 to the first quarter of 1983, and to zero otherwise.

4/ Expected inflation is calculated as the sum of the eight lagged values of price inflation multiplied by their respective coefficients in equation (8), divided by the sum of these coefficients.

half of this rise is ascribed to demographic factors and the rest to other factors represented by the shift dummy.1/

3. Difficulties of the Phillips-curve approach

The Phillips-curve approach to estimating the natural rate of unemployment is prone to two types of problem. First, the values for the natural rate derived from the Phillips-curve approach are likely to be subject to considerable estimation error unless they are based on a satisfactory model of wage and price behavior. Incorrect equation specification of the wage and price equations, perhaps due to omitted variables or the imposition of inappropriate restrictions on the coefficients, would bias the coefficient estimates and thus distort the calculated value of the natural rate.

Second, the Phillips-curve approach is limited by its inherent inflexibility. The reliance on dummy variables to represent factors that shift the natural rate is not well suited to tracking movements in the natural rate over time. Moreover, it does not provide an explanation for shifts in the natural rate over time or for deviations of the actual rate from the natural rate during the business cycle.

III. The Reduced-Form Approach

An alternative approach to the estimation of the natural rate of unemployment is based on an equation relating unemployment to the various factors that are thought to influence it. Studies following this approach interpret fluctuations in unemployment as resulting from unexpected shifts in aggregate demand, from other cyclical factors, and from shifts in the underlying structural characteristics of the labor market. In this framework, aggregate demand shocks are usually seen as the main source of unexpected changes in the rate of inflation. The natural rate of unemployment is calculated as the rate that would occur in the absence of such shocks (so that inflation would be correctly anticipated), provided that other cyclical variables were at trend levels.

1. Barro

In a series of studies, Barro has related the unemployment rate to unexpected shifts in aggregate demand and various structural variables, using a measure of unanticipated monetary growth to represent demand

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1/ This calculation takes into account the upward trend of energy and food prices relative to the GNP fixed-weight index and in the effective exchange rate of the U.S. dollar over the period 1977-83; these factors raise the estimate of NAIRU in this period by about 0.1 percentage point. Note that the productivity variable was constructed so as to have an average value of zero, and therefore does not enter into the calculation of NAIRU.

shocks. In a paper published in 1977,1/ Barro used the following equation for the unemployment rate:

$$\log (U/(1-U)) = a_0 + a_1 m + a_2 m_{-1} + a_3 m_{-2} + a_4 C + a_5 MW \quad (10)$$

Unanticipated monetary growth, m, was estimated as the series of residuals from an equation relating the growth in narrow money, M-1, to a distributed lag of growth in M-1, a moving-average measure of "normal" federal expenditure, and the unemployment rate in the previous period. MW is the ratio of the minimum hourly wage rate to average hourly earnings in the private nonfarm sector multiplied by the ratio of the number of nonsupervisory workers covered by minimum wage legislation to total employment. C is a measure of military conscription.2/ Barro estimated equation (10) using annual data over the period 1949-75; he calculated the natural rate of unemployment from this regression by setting all values of m to zero, that is, by assuming that monetary growth was always fully anticipated. On this basis, the natural rate was estimated to rise from 3 1/2 percent in the early 1950s to 6 1/2 percent in the middle 1970s; this increase was attributed to the rising relative value and coverage of the minimum wage over the period, and to the ending of the draft.

In his 1981 paper,3/ Barro reestimated equation (10) over the period 1949-78; he found that, over this longer sample period, the coefficients of conscription and minimum wage variables were not significantly different from zero. In place of these variables, Barro included the ratio of federal purchases of goods and services to GNP in his unemployment equation, hypothesizing that higher levels of federal spending relative to GNP would tend to lower the unemployment rate. With this revised formulation, the natural rate in the middle 1970s was estimated to have been about 6 1/4 percent, compared with about 3 1/4 percent in the early 1950s; the increase was now ascribed to the diminishing relative importance of direct spending by the federal government.

2. Lilien 4/

Lilien argued that a considerable proportion of changes in unemployment are due to variations in its frictional component, that is,

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1/ R.J. Barro, "Unanticipated Money Growth and Unemployment in the United States," American Economic Review, Vol. 67, No. 2, pp. 101-15 (1977).

2/ C is set equal to the ratio of military personnel to the male population aged 15-44 in the period up to the ending of conscription in 1970 and is set to zero thereafter. The draft is hypothesized by Barro to have reduced the natural rate by increasing the incentive to enter higher education or to find employment.

3/ R.J. Barro, "Unanticipated Money Growth and Economic Activity in the United States", in Money, Expectations and Business Cycles, Academic Press, New York (1981).

4/ David M. Lilien, "Sectoral Shifts and Cyclical Unemployment," Journal of Political Economy, vol. 90, no.4, pp. 777-793 (1982).

to changes in the unemployment rate arising from the process of changing jobs. He suggested that frictional unemployment would fluctuate in response to shifts in supply conditions in goods markets that altered the pattern of employment. As an indicator of such shifts in supply conditions, Lilien constructed a measure of the dispersion of rates of change of employment across an 11-sector breakdown of the economy (D).1/

Lilien derived an unemployment equation by modeling the flows into (layoffs) and out of (hires) the stock of unemployed. Layoffs were related to the total change in employment and to the dispersion of changes in employment across sectors. Hiring was related to the stock of unemployment in the previous period and to present and past monetary shocks, measured by Barro's m. Equation (11) represents a typical Lilien unemployment equation:

$$U = b_0 + b_1 D + b_2 m + b_3 m_{-1} + b_4 U_{-1} + b_5 T \qquad (11)$$

where T is a time trend. Lilien defined the natural rate of unemployment (UL) as the unemployment rate that would occur in the absence of monetary shocks, provided that the unemployment rate was at its natural value in the previous period.2/ UL may be obtained from the expression:

$$UL = \sum_{i=0}^{\infty} b_4^{\,i} (b_o + b_1 D_{-i} + b_5 T_{-i}) \qquad (12)$$

Lilien estimated equation (11) using annual data over the period 1949-81. On the basis of the regression results, he calculated that the natural rate ranged from 4 to 5 1/2 percent in the 1950s, from 4 to 5 percent in the 1960s, and from 5 1/2 to 8 percent in the 1970s. He observed that the estimated discrepancies between actual and natural rates were much more pronounced in the 1960s than in the 1970s. Lilien interpreted this as indicating that monetary surprises were responsible for much of the cyclical fluctuation in the unemployment rate during the 1960s, while shifts in supply conditions were the dominant factor behind swings in the unemployment rate during the 1970s.

Lilien's measure of the natural rate may be calculated for the years 1982 and 1983 using Lilien's coefficient estimates and values of dispersion of changes in employment derived from recent data (see Table 1). On this basis, the natural rate of unemployment in these two years equaled 7 1/2 percent, some 2 percentage points less than the actual rate. Only a small fraction of the two-point gap in 1982 can be attributed to the fact that monetary growth was less than anticipated

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1/ D is calculated as $[\sum_j (E_j/E)(\sum_j \Delta\log E_j - \Delta\log E)^2]^{1/2}$, where E_j is employment in industry j, and $E = \sum_j E_j$.

2/ Note that, according to this interpretation, the natural rate would be affected by cyclical swings in frictional unemployment.

(according to Barro's formula); in 1983, a positive monetary shock is estimated to have lowered the unemployment rate slightly. Thus, on the basis of Barro and Lilien's results, the high rates of unemployment in 1982-83 can not be fully explained by either high rates of frictional unemployment or by monetary shocks.

IV. Extensions of the Reduced-Form Approach

This section addresses three issues arising from Barro's and Lilien's work. First, the findings of Barro and Lilien do not rule out the possibility that structural conditions have a strong influence on the unemployment rate; but these authors do not include such variables in their preferred equations. The first part of this section seeks to identify structural variables that do have a well-determined relationship with the unemployment rate. Second, Barro and Lilien do not allow for the possibility that the unemployment rate may be affected by movements in aggregate demand coming from sources other than unanticipated changes in monetary growth. The second part of this section investigates whether other sources of changes in aggregate demand may influence the unemployment rate. Third, Lilien does not test his hypothesis that the dispersion of rates of change in employment across sectors is a good measure of shifts in supply conditions. The third part of this section examines the possibility that the dispersion variable may not principally reflect supply shocks but may rather be endogenously determined or related to shifts in aggregate demand.

1. The influence of structural conditions in the labor market

Eight measures of structural conditions in labor markets were constructed, representing both demographic and non-demographic factors. IB is defined as the ratio of average weekly benefits from state unemployment insurance to average weekly earnings of production workers in the private nonagricultural sectors; IC is defined as the percentage of the civilian labor force covered by state unemployment insurance; LF, LZ, LY, and LN are the proportions of women, women of childbearing age (aged between 25 and 44), teenagers, and nonwhites, respectively, in the labor force (Table 2). Minimum wage and military conscription variables were constructed as defined by Barro. It is hypothesized that the rate of unemployment is negatively related to the conscription variable and positively related to the other variables. Higher values of the benefits from and coverage of unemployment insurance and a lower degree of military conscription would reduce the cost of being unemployed and therefore tend to raise the unemployment rate; higher proportions of women, teenagers and nonwhites in the labor force would increase the rate of turnover and hence would tend to raise the unemployment rate; a higher value of the minimum wage would reduce employment opportunities for unskilled workers and therefore tend to raise the unemployment rate.

To provide a standard for comparison, equation (11) was re-estimated using annual data over the period 1949-82:

$$U = -0.2 - 20.3\,m - 33.0\,m_{-1} + 59.2\,D \qquad (13)$$
$$\quad (0.4) \quad (2.6) \quad (3.8) \quad (5.5)$$

$$+ 0.08\,T + 0.53\,U_{-1}$$
$$(5.9) \quad (6.5)$$

$$\overline{R}^2 = 0.89 \qquad h = -1.85 \qquad SEE = 0.57$$

Coefficient values in equation (13) are similar to those reported in Lilien.1/ When the eight structural variables were included in equation (13), the coefficients on unemployment insurance benefits, conscription, and the proportion of women of child-bearing age in the labor force had the expected signs, although only that on the unemployment insurance benefits variable was significantly different from zero at the 95 percent confidence level; the coefficients on the other five variables had signs opposite from those expected. In a second regression, these five variables were omitted; in this regression the coefficients on unemployment insurance benefits and the proportion of women of child-bearing age were both significant and had the expected signs, while the coefficients on the conscription variable and also the time trend were not significant. Omitting these latter terms gave the equation:

$$U = -14.0 - 15.6\,m - 27.6\,m_{-1} + 38.7\,D \qquad (14)$$
$$\quad (8.3) \quad (2.6) \quad (4.1) \quad (5.3)$$

$$+ 33.4\,IB + 18.1\,LZ + 0.44\,U_{-1}$$
$$(6.8) \quad (3.3) \quad (5.5)$$

$$\overline{R}^2 = 0.93 \qquad h = -0.51 \qquad SEE = 0.43$$

According to equation (14), the ratio of benefits from unemployment insurance to weekly earnings and the proportion of women of child-bearing age in the labor force both have significant positive effects on the unemployment rate. The coefficients on unexpected monetary growth in equation (14) are not much different from those in equation (13); the coefficient on the dispersion of employment changes is substantially reduced but is still highly significant.

2. The role of anticipated movements in aggregate demand

Equation (14) suggests that unanticipated movements of the money supply may influence the rate of unemployment; this does not exclude the possibility that anticipated shifts in aggregate demand (or unexpected shifts in demand from other sources) may also affect the unemployment rate. It can be argued that any cyclical fluctuation in aggregate demand would affect the demand for labor and hence the unemployment rate, whether or not it was expected. To the extent that an increase in

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1/ Further equations including additional lags of D and m were estimated, as in Lilien, op. cit., but without yielding any significant improvement in performance.

labor demand led to a rise in the wage rate relative to prices, expected future wages or unemployment insurance benefits, this rise would increase the incentive to work at that moment in time. This effect may contribute to the significance of the unemployment insurance benefits variable in equation (14). To be sure, in certain sectors of the economy, wages may respond only sluggishly to fluctuations in labor demand, due to multiyear contracts or other institutional rigidities. In industries affected by such wage stickiness, the labor market may not clear continuously and willing workers would not always be able to obtain employment. In these sectors, the variation of labor demand over the business cycle could lead directly to changes in unemployment, without necessarily having any impact on relative wages.

In his studies, Barro attempted to test for the influence of anticipated monetary growth on unemployment by including the current and lagged values of the rate of growth of M-1 (along with his measure of unanticipated monetary growth) in his unemployment equation; he used an F-test to assess the joint significance of the coefficients on the actual monetary growth variables. On this basis, he concluded that the contribution of anticipated monetary growth to movements of unemployment was unimportant. The same result is obtained by applying the equivalent tests to equation (14).1/

Evidence that monetary shocks do not fully capture the effect of aggregate demand on unemployment is obtained by using an explicit measure of the cyclical position of the economy, the Federal Reserve Board's index of capacity utilization in the manufacturing sector (CU). The coefficient on this variable in the unemployment equation would be expected to reflect anticipated as well as unanticipated cyclical influences that were not represented by other explanatory variables. Including capacity utilization in the equation gave the result:

$$U = \underset{(0.0)}{-0.02} - \underset{(1.9)}{9.7\, m} - \underset{(3.6)}{20.6\, m_{-1}} + \underset{(2.0)}{16.6\, D} + \underset{(4.3)}{21.8\, IB} \qquad (15)$$

$$+ \underset{(4.0)}{17.9\, LZ} - \underset{(3.7)}{10.1\, CU} + \underset{(5.2)}{0.36\, U_{-1}}$$

$R^2 = 0.95$ $h = 0.94$ $SEE = 0.36$

1/ A collinearity problem may arise to the extent that actual M-1 growth and unanticipated M-1 growth are correlated. As an alternative test, predicted values of M-1 growth, calculated on the basis of Barro's forecasting equation, and its lagged values were included in equation (14). Note that in this case the collinearity problem was reduced to the extent that forecast and forecast errors were orthogonal. But again the inclusion of the additional variables did not yield a significant improvement in the explanatory power of the equation.

On the basis of an F-test, the inclusion of the capacity utilization index leads to a significant improvement in the fit of the regression, suggesting that there are indeed cyclical influences on the unemployment rate that were not captured by equation (14).1/ At the same time, re-estimation of equation (15) without the monetary surprise variables leads to a significant deterioration of fit. Together, these two results imply that, despite the possibility of collinearity between capacity utilization and monetary shocks, the two variables make distinct contributions to the explanation of movements in unemployment.

3. Supply shifts, dispersion of employment changes, and the frictional component of unemployment

In his paper, Lilien argued that a shift in the supply conditions in goods markets could lead to a temporary increase in the frictional component of unemployment during the period in which the structure of production and employment adjusted to the new business environment. As this period of adjustment would tend to be marked by a transitional increase in the dispersion of changes in employment across sectors, Lilien used a measure of such dispersion (D) as a proxy for shifts in supply conditions.

A difficulty with Lilien's analysis is that the dispersion variable may not principally reflect supply shocks but may rather be endogenously determined. Lilien rejected the latter possibility on the basis of a regression of D on its own lagged values and on present and lagged values of monetary shocks; this regression indicated no significant relationship between D and these explanatory variables. It would be desirable, however, to find alternative, more direct measures of shifts in supply conditions facing producers and to demonstrate that D is closely related to such variables.

In constructing measures of shifts in supply conditions facing producers, it should be noted that the impact of a supply shift on frictional unemployment would not necessarily depend on whether the shift had been anticipated. Moreover, the effect on unemployment would be related to the absolute value of the supply shift rather than to its direction, as a shift of employment from industry A to industry B would have the same transitional impact on unemployment as the reverse shift. Two proxies for supply shifts were constructed with these points in mind. The first is the absolute value of the rate of change in the ratio of wholesale prices of intermediate inputs to the wholesale prices of finished goods. This variable is intended to represent changes in the cost of equipment and materials relative to the price of output. The second variable is the absolute value of the rate of change in the merchandise terms of trade. This variable is intended to represent changes in the relative attractiveness of producing for export rather than for the domestic market. It is hypothesized that the rate of unemployment would be positively related to both these variables.

1/ The inclusion of lagged values of capacity utilization did not provide a further significant improvement in fit.

The results of several statistical tests suggest that these two supply-shift variables fail to capture the forces that influence either frictional unemployment or dispersion in employment changes. When the supply-shift variables were added to regressions (13), (14) and (15), their coefficients were found to be positive, but small and insignificantly different from zero. The coefficients on the dispersion of employment changes were not significantly affected. Little improvement was achieved by adding lagged values of the supply-shift variables. Moreover, a regression of the dispersion of employment changes on the supply-shift variables produced coefficients that were insignificantly different from zero at the 95 percent level.1/

In the absence of a satisfactory explanation for variations in the dispersion of employment changes in terms of exogenous variables, it cannot be ruled out that the variable may in fact be determined endogenously. In particular, Lilien did not investigate the possibility that the dispersion of employment changes may basically reflect changes in the unemployment rate itself. It may be hypothesized that a change in the unemployment rate, whether positive or negative, would be associated with an increase in the dispersion of changes in employment across sectors to the extent that different parts of the economy responded differently to fluctuations in overall activity. This argument is given empirical support by a regression of the dispersion of employment changes on the absolute change in the unemployment rate:

$$D = \underset{(7.1)}{0.013} + \underset{(8.2)}{0.012}\,|\Delta U| \qquad (16)$$

$\bar{R}^2 = 0.67$ DW = 2.06 SEE = 0.007

Equation (16) suggests that two thirds of the dispersion of changes in employment across sectors may be explained by absolute changes in the unemployment rate. This would imply that the dispersion variable is indeed determined endogenously, so that the coefficient estimates in equations (13), (14), and (15) would be inconsistent.2/

Using an instrumental variables approach avoids this simultaneity problem while still providing a test for Lilien's thesis that frictional unemployment may have an important cyclical component. Under this approach, the employment dispersion variable in the unemployment equation

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1/ Using actual rather than absolute changes in terms of trade and relative prices led to no improvement in performance.

2/ One could argue that equations (13) and (14), which both include a lagged endogenous variable, would directly imply a close relationship between D and ΔU, and that this is the relationship which equation (16) is picking up. It should be noted, however, that the fit of equation (16) is superior to that found in the simple regression of D on ΔU:

$$D = \underset{(15.8)}{0.024} + \underset{(5.82)}{0.070}\,\Delta U$$

$\bar{R}^2 = 0.50$ DW = 1.82 SEE = 0.009

is replaced by the determinants of absolute changes in unemployment. Satisfactory results are obtained by simply substituting the absolute change of capacity utilization for the dispersion of employment changes in equation (15).1/

$$U = \underset{(0.1)}{0.3} - \underset{(1.8)}{8.0}\, m - \underset{(4.1)}{21.5}\, m_{-1} + \underset{(4.9)}{21.5}\, IB + \underset{(5.2)}{21.0}\, LZ \tag{17}$$

$$- \underset{(5.0)}{10.2}\, CU + \underset{(3.3)}{7.8}\, |\Delta CU| + \underset{(5.3)}{0.28}\, U_{-1}$$

$$\bar{R}^2 = 0.96 \qquad h = 0.22 \qquad SEE = 0.32$$

The coefficient on the absolute change in capacity utilization is significantly positive. This result suggests that, for a given level of economic activity, the larger the absolute change in activity, the higher would be the unemployment rate. It may be noted that the long-run coefficients on the other variables in equation (17) are lower than in equation (15), the coefficients on the monetary shock variables are jointly significant, and the standard error is reduced. Re-estimating equation (17) including the employment dispersion variable gives a significant coefficient on the absolute change in capacity utilization but an insignificant coefficient on the dispersion variable.

V. Accounting for Changes in Unemployment

Equations such as (13), (14), (15) and (17) can be used to break down movements in the unemployment rate between shifts in the natural rate and cyclical fluctuations in unemployment. In this section, equation (17) is used to calculate the path of the natural rate of unemployment in the period 1954-83; it is also used to account for fluctuations around this path in terms of various cyclical influences on unemployment.

1. Shifts in the natural rate

In terms of equation (17), the natural rate of unemployment (UN) may be defined as the rate that would occur if (i) the exogenous variables IB, CU, $|\Delta CU|$, and LZ were set at their cyclically adjusted values, (ii) money supply movements were fully anticipated, and (iii) unemployment had equaled the natural rate in the previous period. Accordingly, the natural rate was calculated from the expression:

$$UN = \sum_{i=0}^{\infty} 0.28^{i}\, (0.3 + 21.5\, IB^{*}_{-i} + 21.0\, LZ^{*}_{-i}$$

$$- 10.2\, CU^{*}_{-i} + 7.8\, |\Delta CU|^{*}_{-i}) \tag{18}$$

1/ The absolute changes in capacity utilization alone explain 33 percent of the variation in the dispersion of employment changes.

where the asterisks indicate cyclically adjusted values of the relevant variables.1/ Equation (18) may be solved to a satisfactory degree of precision by truncating at i = 5.

The natural rate series obtained by solving equation (18) rises from 4 3/4 percent in 1955 to 5 1/2 percent in 1970 and to 7 3/4 percent in 1983 (Chart 1). According to equation (18), the 3/4 percentage point increase in the natural rate between 1955 and 1970 was largely accounted for by increasing unemployment insurance benefits relative to weekly earnings (see tabulation below). The percentage of women of child-bearing age in the labor force in fact fell during the first part of this period, before rising back to its initial level by 1970. From 1970 to the present, the natural rate is estimated to have increased at a much faster pace, at just under 0.2 percentage points per year; three quarters of this increase is attributed to the rising percentage of women of child-bearing age in the labor force.

Shifts in the Natural Rate of Unemployment

(In percentage points)

	1955	1960	1965	1970	1975	1980	1983
Estimated natural rate of unemployment 2/	4.8	4.9	5.1	5.4	6.1	7.2	7.8
Post-1955 increase	—	0.1	0.3	0.6	1.3	2.4	3.0
due to:							
Unemployment insurance	—	0.2	0.4	0.6	0.8	0.9	1.0
Demographic shifts	—	-0.2	-0.2	—	0.5	1.4	1.9

2. Cyclical variations

The cyclical unemployment rate (UC) is defined as the difference between the actual and the natural rates of unemployment. The cyclical unemployment rate has varied within a range of about -2 to 2 percentage points over the past 30 years, registering troughs in 1956, 1969 and 1978 and peaks in 1958, 1975 and 1982 (Table 3).

The coefficients of equation (17) can be used to explain these cyclical variations in terms of movements of the exogenous variables in the equation. Unemployment resulting from unanticipated monetary growth (UM) is given by:

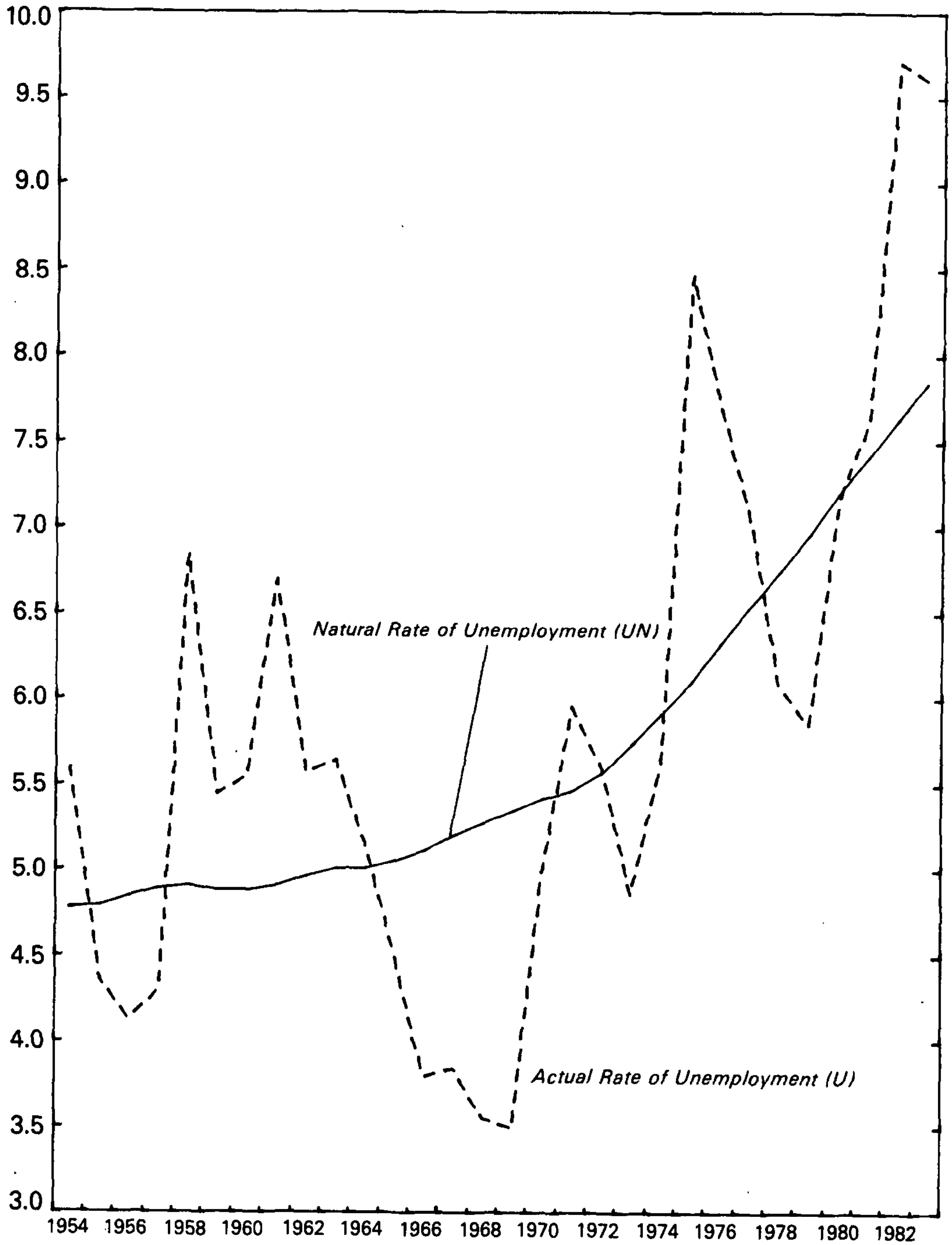
1/ IB* and CU* were derived from trend equations estimated over the period 1957-81; $|\Delta CU|^*$ was set equal to the average value of $|\Delta CU|$ over this period as this variable had no significant trend; LZ* was set equal to LZ as this variable did not vary significantly over the cycle.

2/ Based on equation (18).

CHART 1

UNITED STATES

ACTUAL AND NATURAL RATES OF UNEMPLOYMENT



$$UM = - \sum_{i=0}^{\infty} 0.28^{i} (8.0\, m_{-i} + 21.5\, m_{-i-1}) \quad (19)$$

Unemployment resulting from cyclical variation of frictional unemployment (UF) is given by:

$$UF = \sum_{i=0}^{\infty} 0.28^{i} [7.8 (|\Delta CU|_{-i} - |\Delta CU|^{*}_{-i})] \quad (20)$$

Unemployment resulting from other cyclical factors (UQ) is given by:

$$UQ = \sum_{i=0}^{\infty} 0.28^{i} [21.5 (IB_{-i} - IB^{*}_{-i}) - 10.20 (CU_{-i} - CU^{*}_{-i})] \quad (21)$$

According to equation (19), monetary shocks boosted unemployment above its natural rate by 1/2 percentage point on average between 1957 and 1964, and lowered unemployment below the natural rate by about 1/2 percentage point in the period 1968-74 (see Chart 2 and Table 3). Unexpectedly slow growth of M-1 raised unemployment by 1/4-1/2 percentage point from 1975 to 1977, but positive monetary shocks reduced the unemployment rate in the three following years. In the period 1981-83, monetary shocks are estimated to have had a negligible effect on the unemployment rate.

On the basis of equation (20), the impact on the unemployment rate of cyclical variations in frictional unemployment has generally been smaller than that of monetary shocks. Frictional unemployment was about 1/2 percentage point less than average in 1968-69 and 1/2 percentage point more than average in 1975. At other times, and in particular in 1982 and 1983, the cyclical component of frictional unemployment has been less than 1/4 percentage point.1/

Other cyclical factors (representing deviations from trend of capacity utilization and of unemployment insurance benefits relative to wages) are estimated to have reduced unemployment by 3/4 percentage points in 1955-57 and by about 1 percentage point in 1964-69; they contributed to high cyclical levels of unemployment in 1958-62, in 1970-72 and in 1975-76. These factors were almost entirely responsible for the 2 percentage points of cyclical unemployment in 1982-83. The unexplained residual portion of movements of the unemployment rate has ranged up to 1/2 percentage point in the past, but has been negligible in the past four years.

1/ Estimates of the cyclical variation in frictional unemployment based on the coefficient on employment dispersion in equation (15) are not significantly different from these figures.

VI. The Phillips Curve Revisited

As a way to test the plausibility of the estimates of the natural rate calculated from equation (18), a Phillips-curve price equation similar to the one used by Gordon was estimated using the deviation of the actual rate from the estimated natural rate (i.e., the cyclical unemployment rate UC) to measure the degree of slack in the labor market:1/

$$p^u = \underset{(0.3)}{0.001} - \underset{(5.0)}{0.056}\,UC - \underset{(2.7)}{0.094}\,\Delta UC - \underset{(3.4)}{0.224}\,e + \underset{(6.0)}{0.583}\,f \qquad (23)$$

$$- \underset{(1.6)}{0.069}\,q - \underset{(1.8)}{0.042}\,D1 + \underset{(6.4)}{0.12}\,D2$$

$\bar{R}^2 = 0.71$ DW = 1.94 SEE = 0.009

This regression followed Gordon's procedure described in section II.2 to impose the constraint that the coefficients on lagged values of price inflation should sum to one. The dependent variable (p^u) is unanticipated price inflation; e is the exchange rate variable; q is the productivity variable; f is the relative price of food and energy variable; D1 and D2 are the price control dummy variables.

The results of equation (23) are consistent with the joint hypothesis that (i) the Phillips-curve specification given in Section II.2 is an appropriate form for the price equation and (ii) the cyclical unemployment rate is a satisfactory measure of labor market slack. It may be noted that not only are the coefficients on both cyclical unemployment variables significantly negative, but also the intercept term is insignificantly different from zero. Thus, according to equation (23) and in conformity with the natural rate hypothesis, the rate of inflation would be equal to its expected value if the unemployment rate were equal to its natural rate and exogenous variables were set at trend levels.

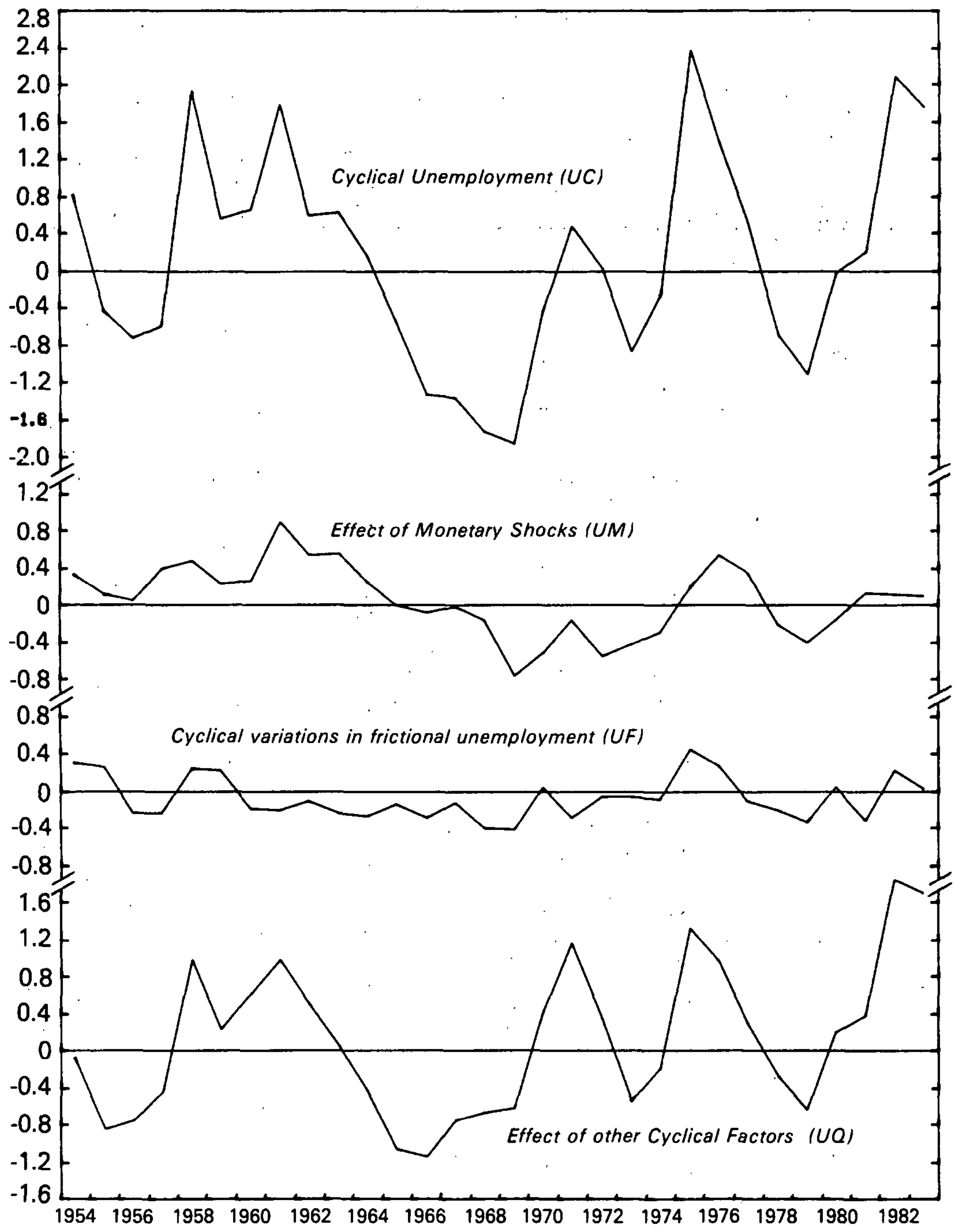
It also appears from equation (23) that the difference between the actual unemployment rate and the estimated natural rate is a better indicator of labor market slack than the Perry-weighted unemployment rate series used in equation (9). First, the coefficients on the cyclical unemployment variables are more precisely determined in equation (23) than are the coefficients on the Perry-weighted unemployment variables in equation (9). Second, when the dummy shift variable D3 is included in equation (23), its coefficient is not significant; this suggests that the estimated natural rate series adequately represents secular factors affecting labor market conditions during the late 1970s and the early 1980s.

1/ Quarterly values for the cyclical unemployment rate were derived by linear interpolation of the annual series for the natural unemployment rate provided in Table 3.

CHART 2

UNITED STATES

CYCLICAL COMPONENTS OF UNEMPLOYMENT



It may be noted that using Lilien's measure of the natural rate as the basis for estimating the excess supply of labor gives less satisfactory results. Re-estimating equation (23) using such a measure of excess supply gives a significantly positive intercept and insignificant coefficients on both cyclical unemployment variables.

VII. Conclusion

The different approaches to estimating the natural rate of unemployment for the United States used in this paper give broadly similar results: (i) there has been a significant increase in the natural rate from the 1960s to the late 1970s and early 1980s amounting to 1 to 2 percentage points; (ii) the natural rate of unemployment was in the range of 7 to 7 3/4 percent in the early 1980s. According to the reduced-form approach, the increase in the natural rate over the last twenty years or so can be ascribed to the rise in the proportion of women of child-bearing age in the labor force and to the rise in unemployment insurance benefits relative to earnings. Deviations of the actual unemployment rate from the natural rate can be related to monetary shocks, to cyclical variations in frictional unemployment and to other cyclical factors. The high rates of cyclical unemployment in 1982 and 1983 seem to have been due mainly to the generally low level of economic activity rather than specifically to monetary shocks or variations in frictional unemployment.

Several difficulties with the Phillips-curve approach were mentioned above. In interpreting the results obtained from the reduced-form approach, a number of caveats should also be borne in mind. First, the approach rests on the implicit assumption that the labor market is essentially a market in which equilibrium is rapidly restored, so that actual unemployment may be seen as fluctuating around the natural rate. If, instead, the labor market were extremely slow to adjust to structural change, then the actual unemployment rate could diverge from the natural rate for prolonged periods which would bias the estimation of the natural rate. If, for example, the decade 1974-83 was genuinely characterized by continuing excess slack due to the labor market's slow response to adverse oil-price and other shocks, this would lead to an overestimation of the true natural rate at the end of that period.

Second, the techique of seeking a single reduced-form equation containing only variables with well-determined coefficients may be inappropriate. The use of a priori sign restrictions and significance tests to narrow the set of possible explanatory variables may be unreliable because of multicollinearity between the variables and difficulties in assessing the correct sign restrictions on the coefficients.1/

1/ For example, it might be argued that a high minimum wage relative to average wage would tend to reduce, rather than increase, unemployment. A higher minimum wage could serve to reduce frictional unemployment by encouraging unskilled workers to accept employment at the minimum wage rather than continuing to search for a better paid job. This effect could more than offset the reduced supply of low wage jobs arising from the minimum wage increase.

Moreover, there is a danger of including in the equations explanatory variables that are in fact jointly determined with the unemployment rate; such inclusion would tend to bias coefficient estimates.

Third, caution would need to be exercised in using the unemployment equation to forecast the natural rate of unemployment. Such a forecast would require a judgment of the movements in the structural factors represented in the equation in the period ahead. Moreover, the equation would only provide a good forecasting tool as long as there were no significant changes in structural factors not included in the equation.

Table 1. Monetary Shocks, Supply Shifts, and Unemployment

	Unanticipated Monetary Growth (m)1/	Minimum Wage (MW)1/	Military Conscription (C)1/	Dispersion of Changes in Employment (D)2/	Rate of Civilian Unemployment (U)	Natural Rate of Unemployment (UL)2/
1949	-0.013	0.180	0.048	0.048	6.1	5.3
1950	0.020	0.323	0.049	0.026	5.2	5.0
1951	0.012	0.301	0.092	0.047	3.0	5.3
1952	0.010	0.284	0.106	0.016	3.6	4.1
1953	-0.017	0.269	0.105	0.031	2.9	3.9
1954	-0.003	0.258	0.099	0.049	5.6	5.4
1955	0.004	0.248	0.090	0.015	4.4	4.5
1956	-0.012	0.307	0.083	0.018	4.1	3.8
1957	-0.015	0.298	0.081	0.023	4.3	4.0
1958	-0.006	0.283	0.075	0.048	6.8	5.5
1959	0.004	0.273	0.073	0.017	5.5	4.9
1960	-0.036	0.262	0.071	0.018	5.5	4.2
1961	-0.007	0.283	0.071	0.028	6.7	4.6
1962	-0.017	0.328	0.077	0.015	5.6	4.3
1963	-0.005	0.325	0.073	0.016	5.6	4.0
1964	0.002	0.334	0.072	0.016	5.2	4.0
1965	0.003	0.325	0.071	0.015	4.5	4.1
1966	0.001	0.315	0.079	0.019	3.8	4.3
1967	-0.003	0.392	0.086	0.022	3.8	4.7
1968	0.027	0.426	0.087	0.016	3.6	4.7
1969	0.017	0.421	0.085	0.016	3.5	4.7
1970	-0.007	0.388	—	0.034	5.0	5.7
1971	0.020	0.364	—	0.031	6.0	6.5
1972	0.009	0.339	—	0.013	5.6	5.8
1973	0.010	0.340	—	0.018	4.9	5.5
1974	-0.006	0.381	—	0.020	5.6	5.6
1975	-0.018	0.385	—	0.057	8.5	7.9
1976	-0.012	0.396	—	0.014	7.7	7.1
1977	0.009	0.370	—	0.015	7.1	6.3
1978	0.014	0.397	—	0.017	6.1	6.2
1979	0.005	0.402	—	0.018	5.9	6.1
1980	-0.008	0.400	—	0.030	7.2	6.7
1981	0.000	0.399	—	0.024	7.6	7.0
1982	-0.011	0.378	—	0.034	9.7	7.6
1983	0.021	0.363	—	0.022	9.6	7.4

1/ Calculated according to formula provided in Barro, op. cit. (1977).
2/ Calculated according to formula provided in Lilien, op. cit. (1982).

Table 2. Indicators of Labor Market Structure 1/

	Ratio of Unemployment Insurance Benefits to Earnings (IB)	Coverage of Unemployment Insurance (IC)	Proportion of the Civilian Labor Force			
			Women (LF)	Youth (LY)	Women Aged 25 - 44 (LZ)	Non-white (LN)
1949	0.408	0.519	0.290	0.070	0.130	...
1950	0.391	0.538	0.296	0.068	0.133	...
1951	0.365	0.579	0.307	0.066	0.139	...
1952	0.376	0.588	0.310	0.065	0.141	...
1953	0.370	0.584	0.308	0.064	0.140	...
1954	0.386	0.563	0.309	0.063	0.140	0.107
1955	0.370	0.568	0.316	0.063	0.139	0.107
1956	0.382	0.588	0.322	0.064	0.140	0.107
1957	0.384	0.600	0.325	0.064	0.140	0.107
1958	0.407	0.571	0.327	0.063	0.139	0.109
1959	0.386	0.580	0.329	0.066	0.136	0.108
1960	0.408	0.581	0.334	0.070	0.135	0.111
1961	0.408	0.570	0.338	0.070	0.135	0.111
1962	0.402	0.586	0.340	0.070	0.136	0.111
1963	0.398	0.593	0.344	0.071	0.136	0.111
1964	0.393	0.593	0.348	0.074	0.134	0.112
1965	0.390	0.614	0.352	0.079	0.135	0.112
1966	0.403	0.636	0.360	0.086	0.136	0.112
1967	0.404	0.648	0.367	0.084	0.138	0.112
1968	0.404	0.640	0.371	0.084	0.139	0.111
1969	0.403	0.649	0.378	0.086	0.140	0.111
1970	0.419	0.641	0.381	0.088	0.141	0.111
1971	0.437	0.626	0.382	0.089	0.141	0.112
1972	0.415	0.708	0.385	0.093	0.144	0.112
1973	0.405	0.729	0.389	0.095	0.149	0.115
1974	0.416	0.722	0.394	0.096	0.154	0.116
1975	0.432	0.695	0.400	0.094	0.159	0.117
1976	0.428	0.707	0.405	0.094	0.166	0.118
1977	0.415	0.712	0.410	0.094	0.172	0.120
1978	0.409	0.762	0.417	0.094	0.178	0.123
1979	0.407	0.776	0.421	0.092	0.184	0.124
1980	0.421	0.813	0.425	0.088	0.191	0.125
1981	0.417	0.800	0.430	0.083	0.197	0.125
1982	0.443	0.792	0.433	0.077	0.203	0.128
1983 2/	0.440	0.780	0.437	0.073	0.209	0.130

1/ As defined in text.
2/ Estimates based on partial data.

Table 3. Components of Unemployment

	Civilian Unem-ploy-ment (U)	Natural Rate of Unem-ploy-ment (UN)1/	Cyclical Unem-ploy-ment Rate (UC)2/	Unem-ploy-ment due to Unanti-cipated Monetary Growth (UM)3/	Cyclical Variation of Fric-tional Unem-ploy-ment (UF)4/	Unem-ploy-ment due to other Cyclical Factors (UQ)5/	Unex-plained Resi-dual (UU)6/
1954	5.6	4.8	0.8	0.3	0.3	-0.1	0.3
1955	4.4	4.8	-0.4	0.1	0.3	-0.9	—
1956	4.1	4.8	-0.7	—	-0.2	-0.7	0.2
1957	4.3	4.9	-0.6	0.4	-0.2	-0.4	-0.3
1958	6.8	4.9	1.9	0.5	0.2	1.0	0.2
1959	5.5	4.9	0.6	0.2	0.2	-0.2	-0.1
1960	5.5	4.9	0.6	0.3	-0.2	0.6	—
1961	6.7	4.9	1.8	0.9	-0.2	1.0	0.1
1962	5.6	5.0	0.6	0.5	-0.1	0.5	-0.4
1963	5.6	5.0	0.6	0.6	-0.2	—	0.3
1964	5.2	5.0	0.2	0.2	-0.3	-0.4	0.6
1965	4.5	5.1	-0.6	—	-0.1	-1.1	0.6
1966	3.8	5.1	-1.3	-0.1	-0.3	-1.2	0.2
1967	3.8	5.2	-1.4	—	-0.1	-0.7	-0.5
1968	3.6	5.3	-1.7	-0.2	-0.4	-0.7	-0.5
1969	3.5	5.4	-1.9	-0.8	-0.4	-0.7	-0.1
1970	5.0	5.4	-0.4	-0.5	—	0.5	-0.4
1971	6.0	5.5	0.5	-0.2	-0.3	1.2	-0.2
1972	5.6	5.6	—	-0.5	—	0.3	0.3
1973	4.9	5.7	-0.8	-0.4	-0.1	-0.5	0.2
1974	5.6	5.9	-0.3	-0.3	-0.1	-0.2	0.3
1975	8.5	6.1	2.4	0.2	0.5	1.3	0.4
1976	7.7	6.3	1.4	0.5	0.3	0.9	-0.4
1977	7.1	6.5	0.6	0.3	-0.1	0.3	—
1978	6.7	6.8	-0.1	-0.2	-0.2	-0.3	—
1979	5.9	7.0	-1.1	-0.4	-0.3	-0.6	0.3
1980	7.2	7.2	—	-0.2	—	0.2	-0.1
1981	7.6	7.4	0.2	0.1	-0.3	0.3	—
1982	9.7	7.6	2.1	0.1	0.2	1.9	-0.1
1983	9.6	7.8	1.8	0.1	—	1.7	-0.1

1/ Calculated according to equation (17).
2/ UC=U-UN.
3/ Calculated according to equation (19).
4/ Calculated according to equation (20).
5/ Calculated according to equation (21).
6/ UU=UC-UM-UF-UQ.