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Why is Unemployment So High at Full Capacity? The Persistence of Unemployment, the Natural Rate, and Potential Output in the Federal Republic of Germany

Prepared by David T. Coe and Thomas Krueger*

Authorized for Distribution by Peter B. Clark

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Abstract

The empirical analysis indicates that in the Federal Republic the unemployed primarily influence the relationship between the level of real wages and productivity, rather than the growth of wages. This result suggests a distinction between an equilibrium natural rate of unemployment, which is estimated to have been 3-4 percent in the 1980s, and a quasi-equilibrium unemployment rate closer to actual rates of 7-8 percent. Corresponding to these two concepts of equilibrium unemployment, estimates are presented of alternative concepts of potential output that differ according to whether labor input is consistent with the quasi-equilibrium rate of unemployment or with the natural rate of unemployment.

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Contents

Summary

In the Federal Republic of Germany in the late 1980s, the coexistence of persistently high rates of unemployment, stable wage and price inflation, and output at or near capacity could be interpreted as implying that the unemployment rate, which was about 8 percent, was at the natural rate of unemployment. It is difficult, however, to identify structural changes in the labor market in the Federal Republic that would have increased the natural rate of unemployment from less than 1 percent in the 1960s to 7-8 percent in the 1980s. Moreover, the rapid rates of growth and the substantial declines in the unemployment rate in 1989 and 1990 did not appear to be accompanied by increases in inflationary pressures, suggesting the existence of available capacity.

The empirical analysis presented in this paper suggests that the natural rate of unemployment in the Federal Republic increased to 3-4 percent in the 1980s, well below actual rates of unemployment. The empirical results also indicate that wages in the Federal Republic have been primarily determined by bargaining between employers and employees, with the unemployed having little influence on the growth of wages; this model of wage determination implies that persistent unemployment above the natural rate is not inconsistent with stable wage and price inflation. This suggests a distinction between the concept of an equilibrium natural rate of unemployment and a quasi-equilibrium unemployment rate that may be closely related to the actual rate of unemployment. Corresponding to these two concepts of equilibrium unemployment are alternative concepts of potential output that differ according to whether labor input is consistent with the quasi-equilibrium rate of unemployment or with the natural rate of unemployment.

The paper discusses the implications of two alternative models of wage determination regarding the persistence of unemployment, and tests which model is most consistent with aggregate wage developments in the Federal Republic. It also derives consistent estimates of potential output and the natural rate of unemployment, where both are explicitly related to structural aspects of the labor market and policy variables, and analyzes their determinants.

I. Introduction: Why is Unemployment so High at Full Capacity?

Potential output and the natural rate of unemployment are closely related concepts describing long-run equilibria in product and labor markets. Both concepts have important policy implications because they summarize sustainable rates of growth and unemployment in the long run; and, in conjunction with actual output and unemployment, they are important determinants of wage and price developments in the short run. These are now particularly important policy concerns in the Federal Republic of Germany (FRG) because unification with the German Democratic Republic (GDR) implies a significant increase in demand, a demand stimulus that is already apparent in 1990. In the long run, the path of potential output, and hence productivity at potential output, in the FRG will determine the magnitude of the "catch up" that is required for living standards in the German Democratic Republic to match those in the Federal Republic. 1/

Economic developments in the Federal Republic in the 1980s suggest that the relationship between potential output, the natural rate of unemployment, and wage and price inflation may not be straightforward: output expanded steadily after 1982 and, based on most measures, appeared to be at or near capacity in the late 1980s while wage and price inflation was broadly stable; 2/ but unemployment rates, after increasing dramatically in the mid-1970s and early 1980s, remained stuck at historically high levels of about 8 percent until 1988 (Chart 1).

The coexistence of persistent high rates of unemployment, low and stable wage and price inflation, and output that appeared to be at or near capacity would be consistent with the standard Phillips curve model if the natural rate of unemployment was also about 8 percent in the mid to late 1980s. It is difficult, however, to identify structural changes in the labor market that would have increased the natural rate of unemployment from less than 1 percent in the 1960s and early 1970s to 7 to 8 percent in the 1980s. 3/ Moreover, the rapid rates of growth and the substantial declines in the unemployment rate in 1989-90 did not appear to be

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1/ An estimate of this productivity gap is the starting point for most empirical analyses of the effects of German economic, monetary, and social union; see Masson and Meredith (1990) and the references cited therein. Throughout the paper FRG refers to the pre-unification territory of the Federal Republic of Germany.

2/ Capacity utilization in manufacturing in the late 1980s was at its highest level for over a decade; see European Economic Community (1990) and International Monetary Fund (1990), Chart 9.

3/ Unemployment in the FRG averaged less than 1 percent in the 15 years to 1974 and was never greater than 2 percent. A number of studies based on estimated Phillips curves have calculated that the non-accelerating inflation rate of unemployment (the NAIRU) increased to 7 to 8 percent in the mid-1980s. These estimated increases in the NAIRU were not related to changes in structural aspects of the labor market but reflected increases in unemployment needed to offset the inflation implications of developments such as increases in import prices or secular declines in productivity growth. See, for example, the alternative calculations of the NAIRU presented in Table 8 of Coe (1985), Franz and König (1986), and Franz (1987).

accompanied by significant increases in inflation pressures, suggesting the existence of some excess capacity.

The empirical analysis presented in this paper suggests an alternative explanation for the coexistence of persistent high rates of unemployment, stable inflation, and output at capacity, an explanation that focuses on the wage bargaining process and other structural features of the labor market. It is argued that, although there has been some increase in structural unemployment since the early 1970s, the natural rate of unemployment in the FRG was well below the actual unemployment rate for most of the 1980s. But because of the nature of wage bargaining in the FRG, the large gap between the actual and the natural rates of unemployment did not exert ongoing downward pressure on the growth of real wages, but rather had a one-time effect on the relationship between the level of real wages and trend labor productivity. In this model, unemployment above the natural rate is consistent with stable wage and price inflation because wages are not determined by a Phillips curve relationship, but by a target-real-wage-bargaining model.

This suggests a distinction between the concept of an equilibrium natural rate of unemployment and a quasi-equilibrium unemployment rate that may be closely related to the actual rate of unemployment, as suggested by the hysteresis hypothesis. 1/ Corresponding to these two concepts of equilibrium unemployment are alternative concepts of potential output that differ according to whether labor input is consistent with the quasi-equilibrium rate of unemployment--quasi-potential output--or with the natural rate of unemployment.

Actual output in the FRG may have been near quasi-potential output for much of the 1980s, as suggested by most indicators of capacity utilization. However, a measure of potential output using labor input consistent with the natural rate of unemployment would have indicated that more resources were available to increase output than suggested by the quasi-equilibrium measure of potential. This does not mean, however, that there were no constraints or "speed limits" on the rapidity with which output could be increased and unemployment reduced from their quasi-equilibrium levels. An obvious constraint was the existing stock of capital, suggesting the possibility of capital-shortage unemployment. But developments in 1989-90 underscore that this is a short-run constraint that is not binding over the medium term, as higher rates of investment can be expected to be forthcoming in response to high rates of capacity utilization and an increase in actual or expected demand. 2/

The objectives of this paper are threefold. The first is to describe more fully the implications of the alternative models of wage determination

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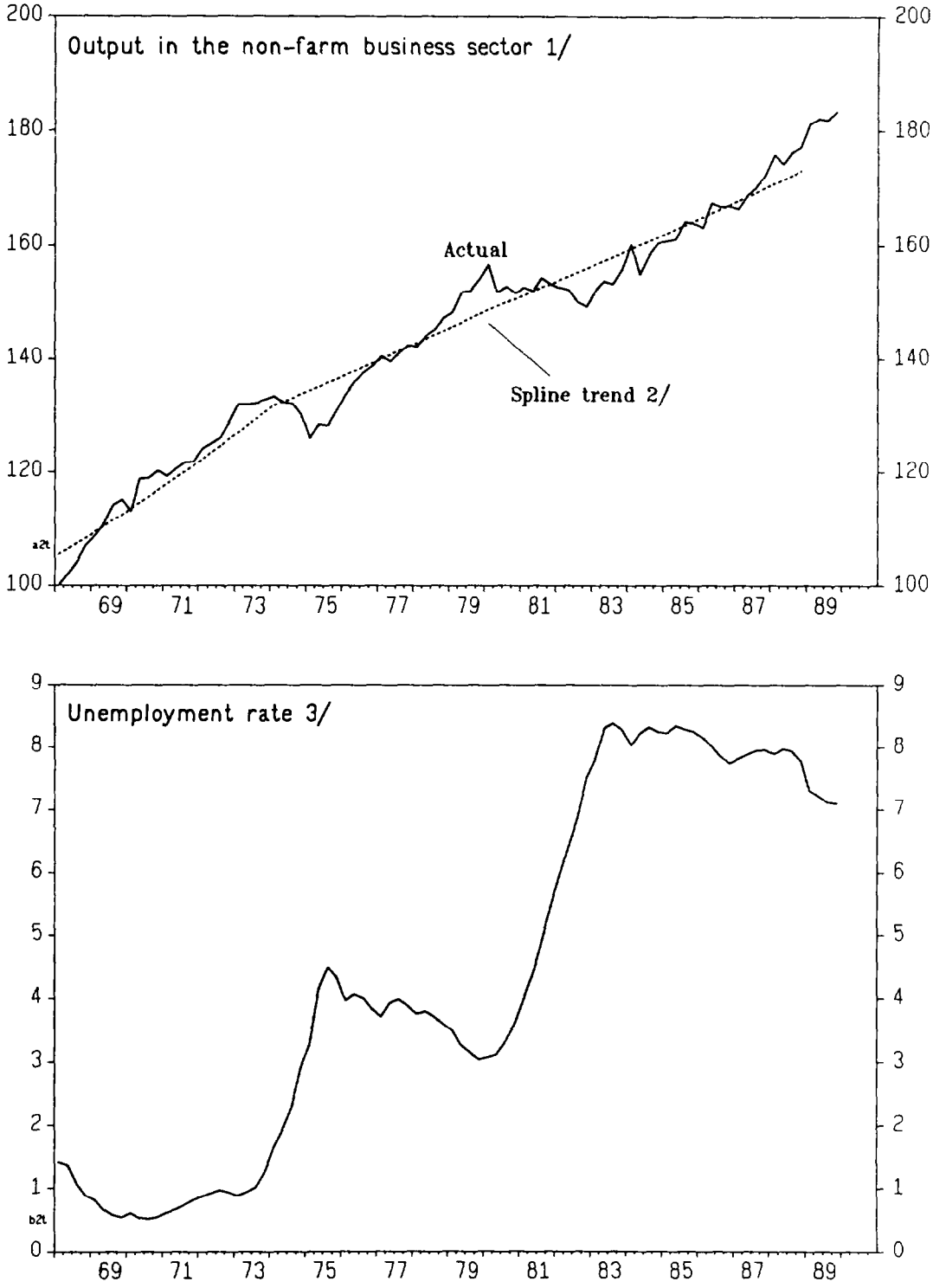
1/ See Blanchard and Summers (1986) and the papers in Cross (1988).

2/ This point is emphasized in Bean (1989). In the labor market there may also be speed limits to reductions in unemployment if, for example, changes in unemployment have direct impacts on wage growth.

Chart 1
Federal Republic of Germany
Output and Unemployment



1/ Actual output in 1968:I = 100.

2/ Estimated from 1968:I to 1988:IV allowing for changes in trend growth in 1974:I and 1980:I.

3/ In percent of the labor force.

noted above, and test which model is most consistent with aggregate wage developments in the FRG (Section II). The second objective is to estimate a system of equations which can be used to derive consistent estimates of potential output and the natural rate of unemployment where both are explicitly related to underlying structural or policy variables (Section III). The third objective is to present a decomposition of past and prospective developments in potential output and the natural rate of unemployment in the Federal Republic (Section IV).

II. Wage Determination

In the 1970s and 1980s, unemployment and output developments in many European countries were similar to those depicted for the FRG in Chart 1. This apparent inconsistency with the Phillips curve/natural-rate model led to the development of theoretical labor market models that provided consistent micro-foundations to explain the persistence of involuntary unemployment. 1/ Section II.1 discusses the aggregate wage and unemployment dynamics implied by the target-real-wage-bargaining model--an aggregate model of wage determination consistent in many respects with these theoretical labor market models--as opposed to a conventional Phillips curve/natural-rate model. Section II.2 presents a test of which model best characterizes aggregate wage determination in the Federal Republic.

1. The Phillips curve/natural-rate model and the target-real-wage-bargaining model

Institutional features of the labor market in the FRG indicate that the number of unemployed have little influence on the wage bargain struck between employees and employers. Bargaining, for example, is highly centralized and settlements negotiated by unions in key industries or sectors are often extended to include smaller establishments or the non-unionized workforce. 2/ Furthermore, unemployment benefits make up a significant portion of lost wage income, and basic benefits (Arbeitslosenhilfe) can, in principle, continue indefinitely after eligibility for unemployment insurance has expired, provided a social need exists on the part of the recipient. These features give the employed workforce a sufficient degree of market power that the process whereby the unemployed effectively underbid wages until only structural unemployment

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1/ These models, which are not necessarily mutually exclusive, focus on the relationship between employers and employees and include insider-outsider models, implicit contract models, efficiency wage models, union bargaining models, and hysteresis models. See, for example, Oswald (1985), Blanchard and Summers (1986), Carruth and Oswald (1987), Gottfries and Horn (1987), Alogoskoufis and Manning (1988), and Lindbeck and Snower (1988).

2/ This feature of the labor market in the FRG is discussed in Burda and Sachs (1987) and Lipschitz et al. (1989) p. 32.

remains, as suggested by the Phillips curve/natural-rate model, may not occur.

An alterative model to the Phillips curve, one that captures some of these features of the labor market, is Sargan's (1964) target-real-wage-bargaining model. 1/ The focus in this model is on the equilibrium relationship between the levels of--as opposed to the changes in--real wages and labor productivity implying that the growth of nominal wages will be determined, in part, by a catch-up variable reflecting past deviations of real wages from their target level. This feature of the target-real-wage-bargaining model results in very different implications for equilibrium unemployment compared with the standard Phillips curve/natural-rate model. Before presenting a nested specification of the two models, the relationship between the two models is presented in terms of the familiar Phillips curve graph.

The top panel of Chart 2 shows the expectations-augmented Phillips curve with a vertical long-run Phillips curve at the natural rate of unemployment (U*). Aggregate demand is represented as a positive relationship between nominal wage inflation (Δw) and unemployment (U) implying that, in the short run, higher inflation will reduce aggregate demand for real output. 2/ Consider the influence of restrictive monetary policies adopted to reduce wage and price inflation. From an initial equilibrium position of wage inflation at Δw_0 and unemployment at the natural rate, the more restrictive policies would reduce aggregate demand (AD_0 to AD_1) and increase unemployment to U_1. As the declines in wage inflation are incorporated into inflation expectations, the short-run Phillips curves (PC) shift down, real wages decline, and unemployment falls. 3/ This process--which is the mirror image of Friedman's (1968) accelerationist hypothesis--continues until equilibrium is re-established at the natural rate (U^*) and wage and price inflation is reduced to Δw_1.

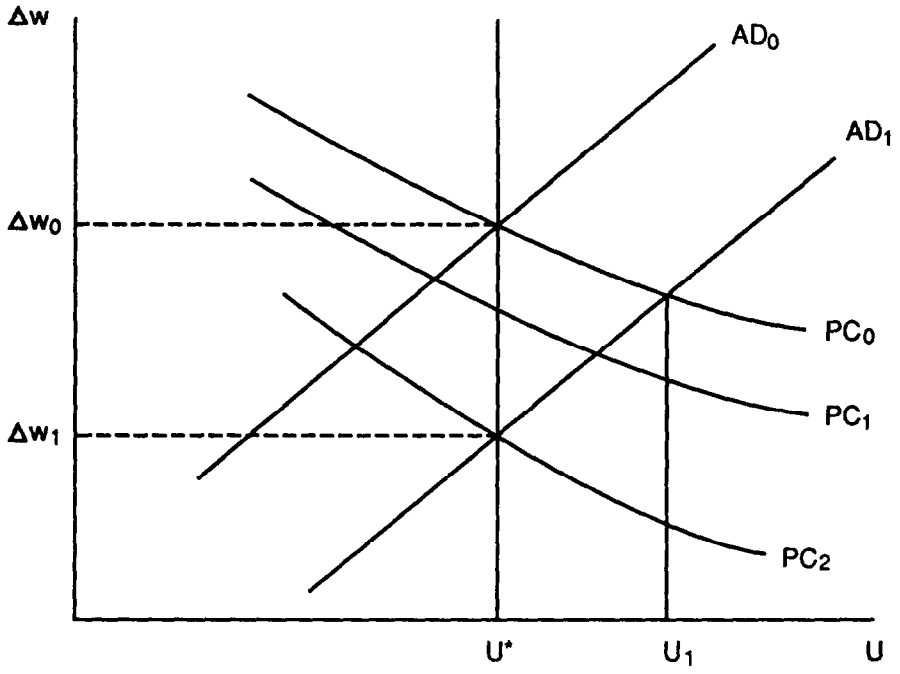
1/ See also Kuh's (1967) productivity theory of wages.

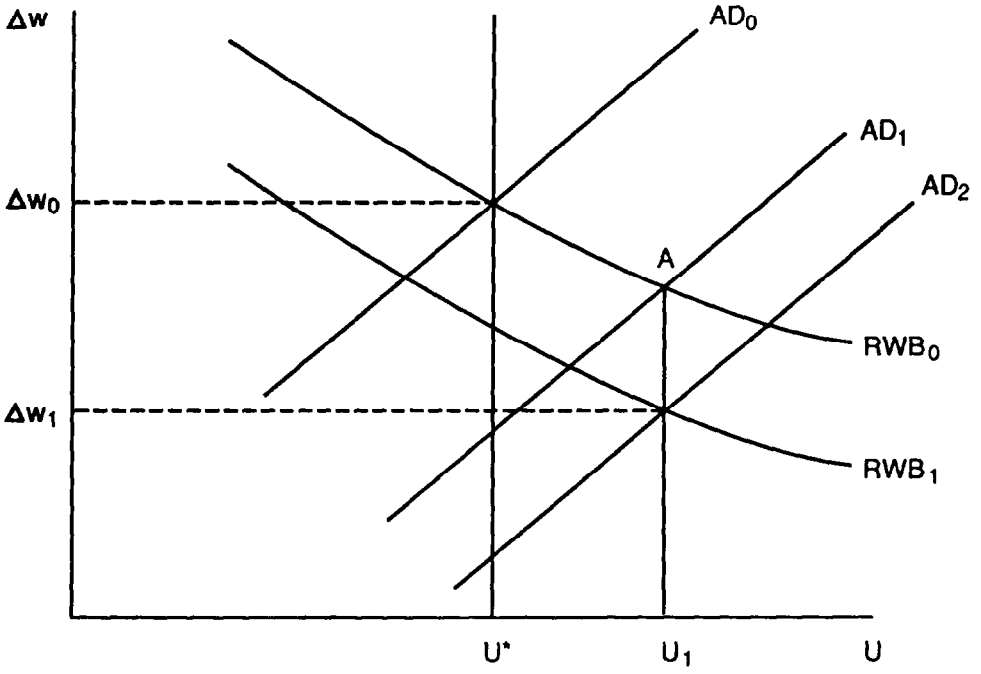
2/ Dornbusch and Fischer (1981, pp. 429-51) derive a similar aggregate demand curve in terms of inflation and the level of output.

3/ The aggregate demand curves also shift down with the declines in inflation expectations giving a clockwise path to the new equilibrium at (Δw_1,U*); these shifts of the AD curve are not shown in Chart 2. The description given above of the dynamics of a policy-induced disinflationary process is broadly consistent with developments in the United States in the early to mid-1980s, although macroeconomic policies, particularly fiscal policies, were not consistently restrictive and import price developments provided additional stimulus to the disinflation process. Note that the change formulation of the Phillips curve implies that transitory disturbances can have permanent effects on the real wage; this is one of the main theoretical problems with the Phillips curve discussed by Blanchard and Fischer (1989), pp. 542-6.

Chart 2

The Phillips Curve/Natural-Rate and Target-Real-Wage-Bargaining Models





In the lower panel of Chart 2, the short-run Phillips curve has been replaced with a real-wage-bargaining curve (RWB). The only difference between the real-wage-bargaining curve and the Phillips curve, is that nominal wage growth will now be influenced by an additional catch-up variable reflecting the deviation of real wages from their target level (as shown in the specification of equation (1) below). Just as in the Phillips curve, the real-wage-bargaining curves will shift with changes in expected inflation.

Consider the impact of the same restrictive monetary policies in the target-real-wage-bargaining model. The first-round effects are similar to the Phillips curve model: unemployment increases and nominal wage growth falls to A. Real wages also decline with the increase in unemployment as does the target level of real wages. But once the increase in unemployment has been reflected in a reduction in the target level of real wages, the higher level of unemployment does not exert on-going downward pressures on the growth of real wages; because real wages do not decline further, unemployment does not fall. At point A there are, however, downward pressures on nominal wage growth as the decline in wage inflation gets incorporated into expectations. Consequently, the real-wage bargaining curves (RWB) and the aggregate demand curves (AD) shift down until inflation has been reduced to Δw_1. Although wage and price inflation stabilize at the same level as in the Phillips curve model, reflecting the same reduction in the growth of money, real wages are higher in the target-real-wage-bargaining model--reflecting the market power of the employed labor force--and hence so is unemployment. Thus, in the target-real-wage-bargaining model, unemployment in excess of the natural rate can exist as a quasi-equilibrium with stable wage and price inflation.

The relationship between the target-real-wage-bargaining model and the Phillips curve model shown in Chart 2 can be expressed in the following wage equation which nests the two models: 1/

$$(1) \qquad \Delta w = \Delta p^{exp} + \Delta q^{tr} + \tau_1(U-U^*) + \tau_2(w-p-q^{tr}-\tau_0)_{-1}$$

where $\tau_1 < 0$, $\tau_2 \leq 0$, and τ_0 defines the equilibrium relationship between the level of real wages and trend average labor productivity (q^{tr}). If the final term is absent ($\tau_2=0$), the equation is a relatively standard Phillips curve except that trend productivity growth and the natural rate of unemployment are explicitly specified. Including the final term ($\tau_2<0$), converts the equation from a growth rate relationship between real wages, productivity, and unemployment, to a level relationship between the same variables. This can be seen in the long-run, stationary steady-state form of equation (1), assuming that $\Delta p^{exp}=\Delta p$:

$$(1') \qquad w = p + q^{tr} - (\tau_1/\tau_2)(U-U^*) + \tau_0$$

1/ See Nickell (1988), pp. 215-7 and Coe (1990). Lower-case letters indicate logarithms and $\Delta w = w - w_{-1}$.

Since the level of wages is related to the level of unemployment, the growth of wages is related to changes in unemployment. 1/ In this model, the target real wage ($(w-p)^T$) is determined by trend productivity and the labor market gap, which can be thought of as a proxy for the bargaining power of labor:

$$(w-p)^T = q^{tr} - (\tau_1/\tau_2)(U-U^*) + \tau_0.$$

Consider an equilibrium characterized by realized expectations ($\Delta p^{exp}=\Delta p$) and real wages growing the same as trend productivity ($\Delta w-\Delta p=\Delta q^{tr}$). In the Phillips curve model ($\tau_2=0$ in equation (1)), it is clear that equilibrium defined in this way requires that unemployment be at the natural rate ($U=U^*$). In the target-real-wage-bargaining model ($\tau_2<0$ in equation (1)), a quasi-equilibrium can exist where unemployment is above the natural rate provided that the target level of real wages has been reduced relative to the level of trend productivity; in terms of equation (1), what is required is that the last two terms sum to zero:

$$\tau_1(U-U^*) + \tau_2(w-p-q^{tr}-\tau_0)_{-1} = 0.$$

2. A test of the alternative models

Given that equation (1) nests the Phillips curve/natural-rate model and the target-real-wage-bargaining model, it is straightforward to test which best characterizes aggregate wage formation in the FRG. An estimated version of equation (1) is: 2/

$$\begin{aligned}(2)\quad \Delta w = {} & \underset{(0.28)}{1.107}\ \Delta p^c + \underset{(0.24)}{0.627}\ \theta^4(L)\Delta q - \underset{(0.21)}{0.907}\ (U-DEM) - \underset{(0.03)}{0.068}\ (w-p^c-q^{tr})_{-1} \\ & - \underset{(0.64)}{1.504}\ \Delta(p^c-p) - \underset{(0.54)}{1.999}\ \Delta(p^c-p)_{-1} - \underset{(0.08)}{0.288}\ \Delta w_{-1} \\ & + \underset{(2.35)}{7.206} + \underset{(2.37)}{10.716}\ D(70{:}I,70{:}II) + \underset{(2.38)}{6.016}\ D(84{:}I,84{:}II)\end{aligned}$$

$R^2 = 0.717$ SEE = 3.194 Durbin h = -1.61

1/ Whether the growth of wages is related to the level or the change in unemployment has been suggested as a test for hysteresis; see Coe (1985, 1988), Blanchard and Summers (1986), and Gordon (1990), pp. 1124-6.

2/ The equation is estimated on quarterly, seasonally adjusted data from 1969:I to 1988:IV using PC GIVE version 6.0. Standard errors are shown in parentheses and critical values (CV) at the 5 percent level are shown for the F-statistics. $\theta^4(L)$ denotes a 4-quarter moving average lag operator. Dummy variables are 1 in the first quarter in parentheses and -1 in the second quarter. Δ indicates the (logarithmic) variables have been expressed as first differences and multiplied by 400 to make them comparable to annual percentage changes; $(w-p^c-q^{tr})_{-1}$ has also been multiplied by 400.

F-statistics:

Autocorrelation (1-5) = 1.27 (CV = 2.2)
ARCH (4) = 1.23 (CV = 2.5)
Chow (break in 85:IV) = 0.91 (CV = 1.9)
Chow (break in 79:IV) = 0.65 (CV = 1.7)

The variables are defined below in Table 1. Compared to the specification of equation (1), the estimated equation incorporates dynamics, as implied by the lagged dependent variable, 1/ and uses a demographically-adjusted unemployment rate (U-DEM) rather than the aggregate unemployment rate. 2/ The natural rate of unemployment is implicitly assumed to be constant and is incorporated into the constant term, and trend labor productivity is proxied by a moving average or a spline trend (q^{tr}). In addition, the change in the gap between consumption and output prices (p^c-p) is included as an explanatory variable since employers care primarily about real product wages whereas employees are concerned about real consumption wages. 3/

The test of the alternative models is simply whether the estimated coefficient on the lagged target-real-wage variable (w-p^c-q^{tr}) is significantly different than zero, which it is. The estimation results thus imply that aggregate wage developments in the FRG are better described by the target-real-wage bargaining model than by the Phillips curve/natural-rate model. 4/ The persistence of high unemployment in the FRG can therefore be interpreted as a reflection of the nature of aggregate wage formation rather than as a reflection of a high natural rate of unemployment. If the natural rate of unemployment in the FRG in the late

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1/ The negative estimated coefficient on the lagged dependent variable implies an oscillating geometric lag distribution. This dynamic pattern reflects the volatility of the dependent variable, particularly in the early part of the sample period.

2/ DEM is an adjustment for changes in the age-sex composition of the labor force and is defined as the difference between the actual unemployment rate and an unemployment rate which holds the age-sex composition of the labor force constant. The age groups are years 16-24, 25-54, and 55 and older.

3/ Following the approach suggested by McCallum (1976), future values of inflation were entered in the equation which was then estimated by instrumental variables using money as an instrument for future inflation. This forward-looking specification of inflation expectations performed less well than the specification reported above, a result that is not inconsistent with the annual and, more recently, multi-year bargaining cycles and ex-post indexation that are characteristic of wage bargaining in the FRG. The equation was also estimated allowing for a distinction between short- and long-duration unemployment, but this performed less well than the aggregate demographically-adjusted unemployment rate.

4/ The results reported in the next section provide even stronger support in favor of the target-real-wage-bargaining model.

Table 1: Variable Definitions 1/

y	real output (NF)
y^{pot}	quasi-potential output (NF)
y^{POT}	potential output (NF)
λ	share of employee compensation in total income (NF)
h	total hours worked (NF)
k	real stock of capital (NF)
rd	real stock of research and development capital
FOR	foreign arrivals as a percent of the labor force
NFOR	foreign arrivals less departures as a percent of the labor force
EEC	intra-EEC trade as a percent of EEC GNP
U	unemployment rate
U^{TR}	trend unemployment rate (spline)
U^{NAT}	the natural rate of unemployment
w	hourly compensation per employee (NF)
p^c	implicit deflator for private consumption expenditures
p	implicit output deflator (NF)
p^m	implicit deflator for imports of goods and services
p^x	implicit deflator for exports of goods and services
p^o	price of oil
q	output per hour (NF)
q^{pot}	labor productivity at quasi-potential output (NF)
NWLC	nonwage labor costs as a percent of total wages and salaries
DEM	impact on the unemployment rate of changes in the age-sex composition of the labor force
APP	apprentices as a percent of the labor force
UNION	union members as a percent of the labor force
UIRR	unemployment insurance replacement ratio

1/ NF indicates private nonfarm business sector. Lower-case symbols indicate that the variable is in logarithms; upper case symbols indicate that the variables are in percent. Data sources are given in an appendix.

1980s and early 1990s was not approximately 8 percent, what was it? This issue is addressed in the next section which presents estimates relating the natural rate of unemployment to structural features of the labor market in the FRG.

III. An Empirical Model of the Natural Rate of Unemployment and Potential Output

To estimate empirical counterparts to the unobserved concepts of potential output and the natural rate of unemployment, a research strategy has been adopted that exploits the information contained in the relatively well defined and measured wage, price, output, and unemployment data. This strategy has been implemented by jointly estimating equations for wages, prices, multifactor productivity, and unemployment. The equations are estimated as a system to ensure that the resulting estimates for potential output and the natural rate of unemployment are consistent, and to incorporate as much relevant information as possible in the estimation procedure. 1/ The model is described in Section III.1 and the estimation results are presented in Section III.2. The variables are defined in Table 1, and data sources and summary statistics are provided in the Appendix.

1. Description of the model

The model consists of five equations: a production function, which is used to define potential output and labor productivity at potential output; equations for the level and the growth of wages, both of which are determined, in part, by the natural rate of unemployment and labor productivity at potential output; 2/ an inflation equation determined, in part, by potential output and labor productivity at potential output; and an unemployment rate equation determined, in part, by potential output, and used to define the natural rate of unemployment. The specification of the equations, particularly the lag distributions, partly reflects preliminary single-equation estimation results.

The production function is specified as Cobb-Douglas with the coefficients on labor and capital inputs constrained to equal their factor shares. With this constraint, the dependent variable is multifactor

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1/ This approach to estimating the natural rate and potential output encompasses many of the methods found in the literature; see the discussion in Adams and Coe (1990) where a similar methodology is applied to the United States.

2/ Both the level and the change specifications of the wage equation are included in the system to exploit the information embodied in the relationship between the unemployment gap and the equilibrium level of wages, and in the relationship between changes in the unemployment gap and short-run changes in wages.

productivity--the Solow (1957) "residual"--which is commonly taken as an indicator of technical progress. Following Grilliches (1988), multifactor productivity is determined primarily by the stock of technical knowledge, which is proxied by the stock of research and development capital. Other variables included in the multifactor productivity equation are a proxy for the impact of foreign (non-German) arrivals on the "quality" of labor input, a proxy for increased efficiency related to integration among the countries of the European Economic Community, 1/ and a proxy for the utilization of capital. The specification of the multifactor productivity equation is: 2/

$$(3) \qquad y - \lambda h - (1-\lambda)k = \alpha_0 + \alpha_1 rd + \alpha_2 \theta^8(L)FOR + \alpha_3 EEC + \alpha_4(U-U^{TR}) + \epsilon^y$$

Assuming full utilization of capital and smoothing the long-run determinants of output to express them at their "normal" levels, the multifactor productivity equation is then used to define potential output and labor productivity at potential output:

$$(4) \qquad y^{pot} = \lambda h + (1-\lambda)k + \alpha_0 + \alpha_1 \mathbf{rd} + \alpha_2 \mathbf{FOR} + \alpha_3 \mathbf{EEC}$$

$$(5) \qquad q^{pot} = y^{pot} - h = (\lambda-1)h + (1-\lambda)k + \alpha_0 + \alpha_1 \mathbf{rd} + \alpha_2 \mathbf{FOR} + \alpha_3 \mathbf{EEC}$$

(Bold print indicates that the variables have been smoothed.) The model distinguishes between potential and quasi-potential output: if labor input is defined to be consistent with the natural rate of unemployment, the above expressions define potential output; if, alternatively, the actual level of the unemployment rate is used to define labor input, the expressions would define quasi-potential output. The relationship between potential (y^{POT}) and quasi-potential output (y^{pot}) can be approximated by: 3/

$$y^{POT} \simeq y^{pot} + \lambda(U-U^{NAT})/100$$

Estimation results with the alternative measures indicated that the output gap and labor productivity defined in terms of quasi-potential output did a

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1/ See the discussion about the impact of the unified European market in Baldwin (1989). The utilization of capital is proxied by the deviation of actual unemployment from its spline trend (U^{TR}).

2/ In terms of the cointegration approach discussed below in the context of the wage equations, equation (3) can be interpreted as the cointegrating levels equation determining the long run equilibrium relationship between multifactor productivity and its determinants.

3/ Total hours can be decomposed as H=(H/E)•(E/L)•(L/POP)•POP, where H is total hours worked, E is employment, L is the labor force, and POP is population. In logarithms, and with the identity, E/L=(1-U/100), potential hours worked is $h^{POT} \simeq h + (U-U^{NAT})/100$; using $y^{POT}-y^{pot}=\lambda(h^{POT}-h)$ gives the approximation in the text. For both measures of potential output, the determinants were smoothed either with a quadratic trend (rd, EEC, FOR), a 13-quarter centered moving average (k), or a linear trend (h, L/POP).

better job of explaining wage, price, and unemployment developments in the FRG, and these are used in the estimation results reported below.

Wages are determined by the target-real-wage-bargaining model discussed above, but the estimation is based on the two-step cointegration approach suggested by Engle and Granger (1987). The estimated target-real-wage-bargaining model presented above (equation (2)) is a simple error-correction specification where deviations of the real wage from its target or equilibrium level are reflected in the growth of wages. The variables in the error-correction term of equation (2) $((w-p^c-q^{tr})_{-1})$ will only represent a long-run equilibrium relationship if they satisfy specific statistical properties. In particular, if each variable is integrated of order 1--that is, it must be differenced once to be stationary--a linear combination of these variables must exist which is itself stationary. In this case, the level variables are said to be cointegrated. 1/ The estimated target-real-wage-bargaining equation reported above satisfies the requirement that the level variables are integrated of order 1; 2/ but, based on the test statistics reported in Engle and Yoo (1987), cointegration of the real consumption wage, trend labor productivity, and the unemployment rate is rejected.

Engle and Granger's (1987) two-step procedure involves specifying the error-correction term in the short-run, dynamic equation--analogous to equation (2) above--as the residuals from a long-run, "cointegrating" levels equation. Since real wages, prices, trend productivity, and unemployment were not cointegrated, additional variables--the price gap, net immigration of foreigners as a percentage of the labor force, and nonwage labor costs as a percentage of wages and salaries--were included to give the following cointegrated levels equation: 3/

$$(6) \quad w = \beta_0 + \beta_1 p^c + \beta_2 q^{pot} + \beta_3 (U-U^{NAT}) + \beta_4 (p^c-p) + \beta_5 NWLC + \beta_6 NFOR + \epsilon^w$$

The residuals from this cointegrating regression (ϵ^w) can be interpreted as deviations of real wages from their long-run equilibrium or

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1/ Cointegration is discussed in Engle and Granger (1987), Engle and Yoo (1987), Hendry (1986) and the other articles in the same issue of the Oxford Bulletin of Economics and Statistics, and the survey article by Stock and Watson (1988).

2/ The power of the unit root tests for stationarity, which are reported in the Appendix, is quite low, particularly for short sample periods; cf. Cochrane (1988).

3/ NFOR is defined as immigration less emigration of non-Germans to the FRG. Immigration of citizens of the GDR (Übersiedler) and ethnic Germans from Eastern Europe (Aussiedler) were also entered in the estimated equation but the estimated coefficient was not significant. Over the 1969-88 sample period, the number of these immigrants was small except in 1981:III-IV and in 1987:III-88:IV. Equation (6) also includes a dummy variable equal to 1 in 1969:I-III.

target level, and hence can be used as the "error-correction" term in the short-run dynamic wage inflation equation:

$$(7) \qquad \Delta w = \gamma_1 \Delta p^c + \gamma_2 \theta^4(L)\Delta q + \gamma_3 \Delta(p^c - p) + \gamma_4 \Delta(p^c - p)_{-1} + \gamma_5 \Delta(U - U^{NAT}) + \gamma_6 \Delta\Delta(U - U^{NAT})_{-1} + \gamma_7 \epsilon^w_{-1} + \epsilon^{\Delta w}$$

Compared to equation (2), the level of the unemployment gap has been omitted, since it is in the cointegrating equation, and changes in the unemployment gap have been added. 1/

The output price equation is based on a variable cost markup model. The markup is determined by demand pressures in goods markets as represented by the gap between actual and quasi-potential output. Normalized unit labor cost is defined as a three-year moving average of compensation growth minus the growth of labor productivity at quasi-potential output. In addition, the equation incorporates a temporary impact from changes in import prices reflecting the mechanical way that import prices can affect the value-added deflator. 2/ Preliminary single equation results indicated that the levels of output prices, compensation, productivity, and the output gap were not cointegrated, so the equation is specified in change form: 3/

$$(8) \qquad \Delta p = \delta_1(\theta^{12}(L)\Delta w - \Delta q^{pot}) + \delta_2(\Delta p^m - \Delta p^m_{-2}) + \delta_3(y - y^{pot})_{-1} + \epsilon^p$$

The unemployment rate equation distinguishes between cyclical and structural unemployment. Cyclical and supply-shock unemployment is specified as a function of the output gap, real oil prices, and the terms of trade. Structural unemployment is specified as a function of nonwage labor costs, unionization, the unemployment insurance replacement ratio, and the percent of the labor force in private sector apprenticeship programs. The apprenticeship program is a unique feature of the labor market in the FRG that contributes to the relatively highly skilled labor force, thereby affecting the natural rate of unemployment. Based on preliminary estimation results, the unemployment insurance replacement ratio is specified in conjunction with the change in union density, implying that increases in

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1/ Equation (7) also includes a dummy variable equal to 1 in 1970:I and -1 in 1970:II.

2/ A change in import prices is (by construction) immediately reflected in the GNP deflator, which is a weighted average of the components of aggregate demand (including the subtraction of import prices), but, in general, only gets reflected in the deflators for the components of domestic demand with a lag. Thus changes in import prices often have a temporary impact on aggregate value-added deflators, even though these deflators, in principle, measure prices of domestic output. Equation (8) also includes a dummy variable for 1976:III and a dummy variable equal to 1 in 1977:III and -1 in 1977:IV.

3/ Similarly, when an error-correction term was added to equation (8), the estimated coefficient was insignificant.

unionization will have a larger impact on unemployment the more generous is the unemployment insurance system. Because of the apparent nonstationarity of the unemployment rate over the sample period (cf. Chart 1), and because the levels equation was not cointegrated, the unemployment rate equation is specified in first differences: 1/

$$(9) \quad \Delta(U\text{-}DEM) = \Psi_1\Delta(y-y^{pot}) + \Psi_2\Delta(y-y^{pot})_{-1} + \Psi_3\Delta(p^o-p)_{-3} + \Psi_4\Delta(p^x-p^m)$$
$$+ \Psi_5\Delta APP + \Psi_6\Delta APP_{-1} + \Psi_7\Delta APP_{-2} + \Psi_8\Delta NWLC_{-1} + \Psi_9\Delta UNION \cdot UIRR_{-2}$$
$$+ \Psi_{10}\Delta(U\text{-}DEM)_{-1} + \epsilon^U$$

The long-run, steady-state relationship between unemployment and its structural determinants is used to determine the natural rate of unemployment:

$$(10) \quad U^{NAT} = 0.7 + \Sigma\Delta DEM + ((\Psi_5+\Psi_6+\Psi_7)/(1-\Psi_{10}))\Sigma\Delta APP$$
$$+ (\Psi_8/(1-\Psi_{10}))\Sigma\Delta NWLC + (\Psi_9/(1-\Psi_{10}))\Sigma\Delta UNION\ UIRR$$

where the summations are from 1969:I to t (the omitted time subscript) and 0.7 is the average unemployment rate from 1960 to 1973 (excluding 1967), which is assumed to be the level of the natural rate of unemployment in 1968.

Since potential output and the natural rate of unemployment are unobserved, the expressions for potential output (equation (4)), labor productivity at potential output (equation (5)), and the natural rate of unemployment (equation (10)) must be substituted into each of the five behavioral equations (equations (3), (6)-(9)). In addition, the expression for the residuals of the wage levels equation--w minus the right-hand side of equation (6)--must be substituted into the wage change equation (7). With these substitutions, the system is internally consistent, includes no proxies for trend output or trend productivity growth, and the relationship between the actual and the natural rate of unemployment is explicitly incorporated into the two wage equations. These substitutions, needless to say, give rise to a large number of non-linear parameter restrictions across the five-equation system.

1/ The lag distributions are based on preliminary single equation estimates. Given the hiring and firing practices of firms--as reflected in labor hoarding, for example--few priors were placed on the lag distributions: variables were first entered with current and three lags and then tested down by removing lagged values which were insignificant. A number of immigration variables and the shares of females and youths in the labor force were also tried, as were changes in hours worked, but the estimated coefficients on these variables were always insignificant and/or wrongly signed. Equation (9) also includes dummy variables for 1975:IV and 1976:I.

2. Estimation procedures and results

The equations for multifactor productivity and the wage levels are cointegrating equations which include non-stationary variables. Although the coefficient estimates are consistent and converge rapidly to their true values, the estimated standard errors are biased. If all five equations were estimated simultaneously, the estimated standard errors of some of the coefficient estimates in the three change equations would also be biased. 1/ To avoid this econometric problem, the following iterative procedure was adopted to estimate the five equation system: the two levels equations for multifactor productivity and wages were first estimated simultaneously; based on the resulting "α" parameter estimates, which appear in the expressions for quasi-potential output and labor productivity at quasi-potential, and the "β" parameter estimates which appear in the error-correction term in the wage growth equation, the three change equations for wages, prices, and unemployment were then estimated as a system; based on the resulting "Ψ" parameter estimates which appear in the expression for the natural rate, the two level equations were re-estimated; etc. After six iterations the summary statistics and the estimated coefficients were essentially unchanged from the fifth iteration.

Because of the simultaneous nature of the system, and given that the errors can be expected to be correlated across the five equations, the system has been estimated using non-linear three stage least squares. The system estimation results, based on seasonally adjusted data from 1969:I to 1988:IV are reported in Table 2. In general, the summary statistics indicate that the equations explain a large proportion of developments in multifactor productivity, wages, and unemployment. The relatively low explanatory power for the inflation equation is related to the imposition of homogeneity, as discussed below. There are some indications of serial correlation in some of the equations. 2/ The coefficient estimates are correctly signed and, in general, large relative to their standard errors.

The Durbin-Watson statistics for the multifactor productivity and wage level equations indicate that the independent variables are cointegrated. 3/ The coefficient estimates are consistent, and, since the variables are cointegrated, the equations can be interpreted as describing the long-run

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1/ See Sims, Stock, and Watson (1990).

2/ Although this was not present in the single-equation estimation results.

3/ The relevant test statistics depend on the number of variables included in the cointegrating regression and are not available for the number of variables in equation (6). Excluding the dummy variables, the Durbin-Watson statistic for the cointegrating equation is 1.33; the Dickey-Fuller and augmented Dickey-Fuller test statistics reported in Engle and Yoo (1987) reject that the variables are not cointegrated at the 1 percent level.

Table 2: Three-Stage Least Squares Estimation Results 1/

	Equation				
	1	2	3	4	5
	α_o = 0.022 (.02)	β_o = -0.243 (.02)	γ_1 = 1.593 (.18)	δ_1 = 1.0 (const.)	Ψ_1 = -0.011 (.003)
	α_1 = 0.129 (.009)	β_1 = 1.0 (const.)	γ_2 = 0.351 (.22)	δ_2 = -0.069 (.02)	Ψ_2 = -0.004 (.002)
	α_2 = -0.064 (.007)	β_2 = 1.0 (const.)	γ_3 = -2.399 (.52)	δ_3 = 0.281 (.12)	Ψ_3 = 0.002 (.0006)
	α_3 = 0.012 (.002)	β_3 = -0.022 (.001)	γ_4 = -2.336 (.45)		Ψ_4 = -0.013 (.005)
	α_4 = -0.022 (.002)	β_4 = -0.002 (.0007)	γ_5 = -5.626 (1.78)		Ψ_5 = -3.495 (.59)
		β_5 = 0.014 (.001)	γ_6 = 4.990 (1.88)		Ψ_6 = 5.835 (.99)
		β_6 = -0.005 (.0008)	γ_7 = -0.350 (.07)		Ψ_7 = -2.712 (.59)
					Ψ_8 = 0.066 (.02)
					Ψ_9 = 0.267 (.08)
					Ψ_{10} = 0.705 (.06)
R^2	0.984	0.999	0.692	0.499	0.805
SEE	0.009	0.011	3.116	2.391	0.105
DW (Durbin h)	1.014	1.381	2.388	1.458	(2.785)

1/ The following variables were considered to be endogenous in addition to the dependent variables: output prices, unemployment, and the level and change of output and consumer prices. The instruments were all exogenous and predetermined variables, lagged values of all endogenous variables, and the current and two lags of the logarithm of M2.

equilibrium levels of multifactor productivity and wages. 1/ The estimated coefficient on the error-correction term in the wage change equation (γ_7), the significance of which was the empirical test of the two alternative wage models discussed in Section II.2, is highly significant. This is consistent with the result reported above, namely that the target-real-wage-bargaining model dominates the standard Phillips curve/natural-rate model.

The specification of the system of equations includes a number of restrictions on specific parameters which are tested in Table 3. Homogeneity of wages with respect to prices and labor productivity at potential output is clearly consistent with the data, which is reassuring given the strong theoretical priors. By contrast, homogeneity with respect to unit labor costs does not appear to characterize the 1969-88 sample period for the FRG. Nevertheless, in view of the long-run focus of the subsequent analysis and the implications for profit margin developments along a steady growth path, the unit coefficient on unit labor costs in the price equation has been imposed. Finally, the data do not reject constant returns to scale on labor and capital inputs, or on labor, capital, and R&D inputs.

IV. The Natural Rate of Unemployment and Potential Output

Given the estimated parameters reported above, historical estimates of the natural rate of unemployment and potential output can be calculated; and the prospects for future developments in the natural rate of unemployment and potential output can be assessed based on assumptions or projections of the likely developments in their determinants.

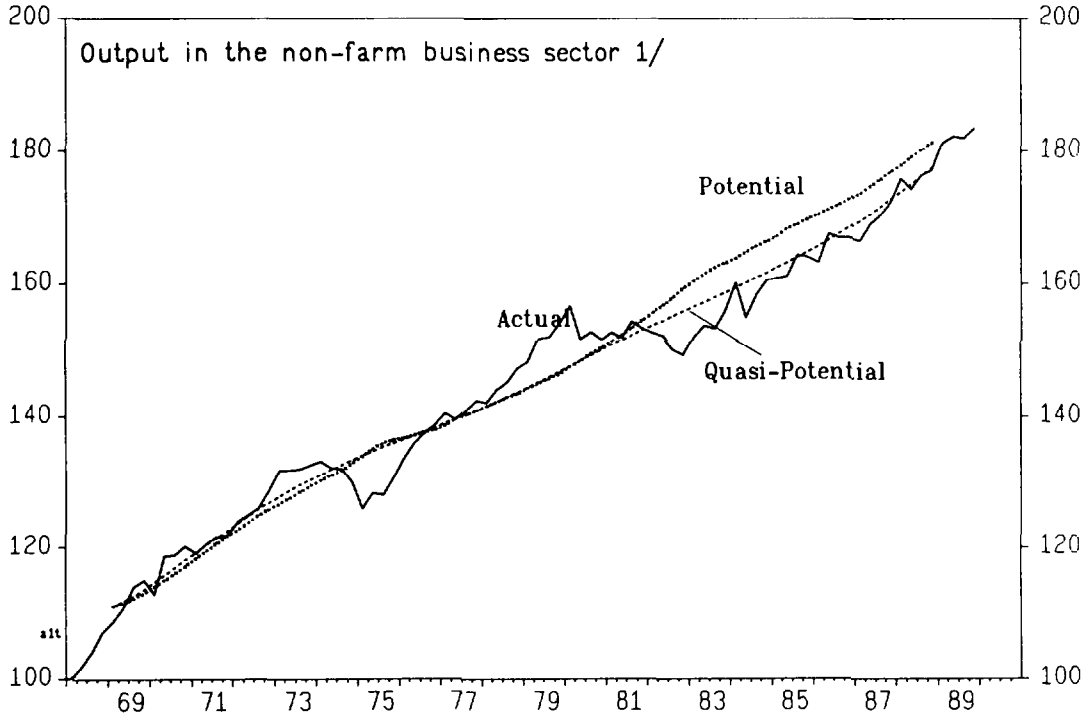
1. The natural rate of unemployment

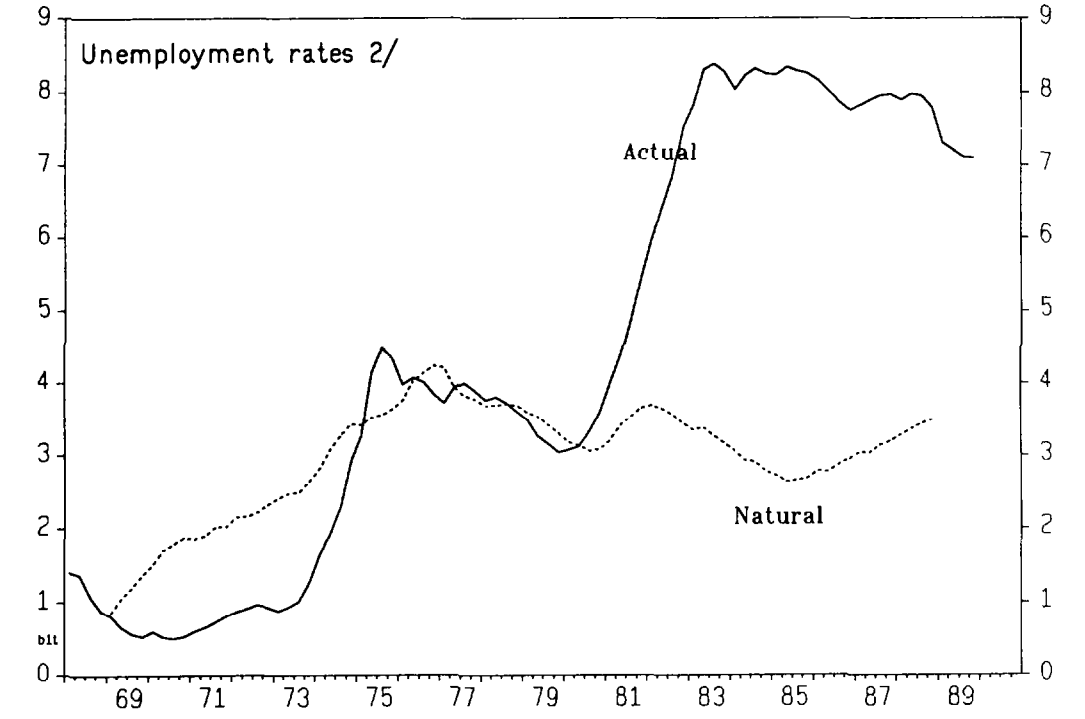
The lower panel of Chart 3 shows the natural rate of unemployment which has been calculated from equation (10) and the estimated long-run parameters reported in Table 2. The natural rate of unemployment is estimated to have increased steadily from its assumed value of 0.7 percent in 1968 to about 4 1/4 percent in 1976, and then to have fluctuated between 2 1/2 and 3 1/2 percent from 1976-88. Actual rates of unemployment were below the estimated natural rate by about 1 1/4 percentage points from 1970-73, and followed closely the natural rate after 1975 until the end of the decade. In the 1980s, however, it is estimated that this gap widened considerably and averaged about 5 percentage points from 1983-88.

1/ Stock (1987) shows that the coefficient estimates are consistent and converge rapidly to their large sample values. However, because the variables are nonstationary, the standard errors are biased downward, and the t-statistics are correspondingly biased upward. Given that all the t-statistics are larger than 7, it seems likely that the estimated coefficients are significantly different from zero.

Chart 3
Federal Republic of Germany

Potential and Quasi-Potential Output and the Natural Rate of Unemployment





1/ Actual output in 1968:I = 100.
2/ In percent of labor force.

Table 3: Tests of the Restrictions in the System Estimates 1/

	Parameter	Test Statistic 2/	Estimated Coefficients Restricted	Estimated Coefficients Unrestricted
Homogeneity				
of wages with respect to				
prices	β_1	0.15	1.0	1.02
productivity at potential	β_2	2.00	1.0	0.92
of inflation with respect to				
unit labor cost growth	δ_1	39.42*	1.0	0.66
Constant returns to 3/				
labor and capital	λ^h, λ^k	0.16	0.55,0.45	0.51,0.42 (Sum = 0.93)
all factors	λ^h, λ^k	0.44	0.41,0.40	0.51,0.42
	α_1, α_3		0.19	0.20 (Sum = 1.13)

1/ These quasi-likelihood ratio tests are based on the system estimation results reported in Table 2.

2/ * indicates the restriction is rejected at the 5 percent confidence level. The test statistic is distributed as χ^2 with the number of restrictions as the degrees of freedom. With 1 restriction the critical value is 3.84 and 2.71 at the 5 and 1 percent confidence level, respectively.

3/ λ^h and λ^k refer to the estimated coefficients on labor (h) and capital (k) inputs, respectively, which replace the factor shares (λ, 1-λ) in the estimates reported in Table 2. The sample period average of total compensation as a percent of national income (λ) is 0.55.

Table 4 presents a decomposition of the changes in the estimated natural rate of unemployment. The large increases in the natural rate in the early 1970s reflected increases in nonwage labor costs, which rose from about 15 percent of wages and salaries in 1969 to 20 percent in 1975, and in unionization, which increased from 29 1/2 percent of the labor force in 1969 to 32 1/2 percent in 1975. During the late 1970s, the natural rate declined somewhat as the number of apprentices increased from 5 percent of the labor force in 1975 to 6 percent in 1979, although this was partially offset by continued increases in nonwage labor costs (1 percentage point) and unionization (2 percentage points). The natural rate of unemployment is estimated to have averaged about 3 1/4 percent in the 1980s reflecting the net effect of some upward pressure from demographic changes, reductions in the share of apprentices in the labor force, and continued increases in nonwage labor costs, offset by reductions in unionization. There was a small increase in unemployment insurance replacement ratios in the mid- to late 1970s, which tended to increase the estimated natural rate of unemployment somewhat, but this effect was largely reversed in the 1980s.

Table 4. The Natural Rate of Unemployment

(In percent of labor force, annual averages)

	1969-73	1973-75	1975-79	1979-83	1983-88
Changes in the unemployment rate	0.4	3.0	-0.8	5.0	-0.3
Changes in the natural rate due to:	1.4	1.0	--	-0.2	0.1
demographics	-0.1	0.1	--	0.3	--
apprentices	0.1	-0.1	-1.3	-0.3	0.4
nonwage labor costs	0.7	0.3	0.4	0.3	0.2
unionization	0.5	0.5	0.8	-0.4	-0.3
unemployment insurance replacement ratios	0.1	0.2	0.2	-0.2	-0.1
Unemployment rates at end year					
Actual	1.0	4.0	3.2	8.2	7.8
Natural	2.5	3.5	3.5	3.3	3.4
Difference	-1.5	0.5	-0.3	4.9	4.4

The 4 1/2 to 5 percentage point gap between the estimated natural rate of unemployment and the actual unemployment rate in the FRG throughout most of the 1980s is striking. It is noteworthy, however, that a number of other studies based on different methodologies arrive at a similar result. Franz and König (1990) estimated a disequilibrium model and calculate an equilibrium structural unemployment rate that was close to actual rates of unemployment in the 1960s, and then increased to a maximum of 3 3/4 percent in 1985. The principal determinants of changes in the structural unemployment rate in Franz and König's analysis were nonwage labor costs and, to a much lesser extent, the unemployment insurance replacement ratio, which is consistent with the results presented above. Similarly, Torres and Martin (1990) based on estimated Phillips curves calculate that the unemployment rate consistent with nonincreasing wage inflation in the FRG rose from about 3 percent in the late 1960s to about 4 percent in 1988. 1/

As discussed in Section II.2, the target-real-wage bargaining model implies that unemployment in excess of the natural rate will result in a downward adjustment of the target real wage relative to labor productivity. Based on the system estimation results, the 5 percentage point gap between the estimated natural rate and the actual unemployment rate implies a reduction in real compensation relative to productivity at potential ($w-p^c-q^{pot}$) of about 11 percent from 1980-88. During this period, the actual increase in real consumption wages ($w-p^c$) was about 10 percent less than the increase in the estimated labor productivity at potential output (q^{pot}). 2/

2. Potential output and multifactor productivity

Based on the system estimation results, the two alternative measures of equilibrium output discussed above--quasi-potential output and potential output--can be calculated. The upper panel of Chart 3 depicts the time paths of potential, quasi-potential, and actual output in the private nonfarm sector of the FRG. There was little difference between potential and quasi-potential output in the 1970s, reflecting the similar levels of the actual and the natural rates of unemployment. Thereafter, the steep rise in the actual rate of unemployment in contrast to the stability in the estimated natural rate of unemployment is reflected in the opening of a gap between potential output and the lower levels of quasi-potential and actual

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1/ In contrast to these results, Jaeger and Parkinson (1990) estimate that the natural rate of unemployment in the FRG in 1988 exceeded 8 percent, the actual rate of unemployment. This result reflects the application of an unobserved-components model that uses capacity utilization to pick up movements in the cyclical component of unemployment. Because the measure of capacity utilization indicates that output was above capacity in 1988, the estimated natural rate of unemployment is, necessarily, above the actual rate of unemployment.

2/ The total impact on real wages from the other variables in the wage level equation roughly summed to zero over this period.

output. Even though this gap narrowed slightly after 1986 as unemployment rates declined, potential output is estimated to have exceeded actual output by about 2 1/2 percent at end-1988; and quasi-potential output is estimated to have been about equal to actual output in 1988.

Table 5. Potential and Quasi-Potential Output Growth in the Private Nonfarm Sector

(Annual percentage changes)

	1969:II -1988:IV	1969:II -1974:I	1974:II -1980:I	1980:II -1988:IV	1983:I -1988:IV	Projection 1989 -1991
Potential output	2.5	3.2	2.1	2.4	2.2	3.0
due to:						
hours worked	-0.4	-0.8	-0.5	-0.2	-0.4	-0.2
capital	1.8	2.4	1.3	1.7	1.8	2.5
multifactor productivity	1.2	1.6	1.3	0.8	0.8	0.7
due to:						
R&D capital	0.6	0.7	0.6	0.6	0.5	0.6
foreign arrivals	0.2	0.3	0.2	0.2	0.2	0.1
EC trade share	0.3	0.6	0.4	0.1	0.1	--
Quasi potential output	2.4	3.4	2.0	2.1	2.2	3.2
Quasi potential hours worked	-0.6	-0.7	-0.6	-0.4	-0.4	0.1
Actual output	2.5	4.2	2.7	1.4	2.9	3.7

The annual growth rate of potential output declined by about 1 percent between the early 1970s and the late 1970s, a decline that was even more pronounced in quasi-potential output growth (Table 5). The growth slowdown reflected primarily a slower pace of capital expansion and a decrease in multifactor productivity growth. Potential output growth increased in the 1980s reflecting increased growth of the capital stock and a slowing in the trend decline of labor input, which were sufficient to offset the continued decline in multifactor productivity growth. During the expansion from 1983-88, however, potential output growth remained more than 1 percentage point lower than in the 1969-73 period.

The slowdown in multifactor productivity growth after 1974 contributed significantly to the lower rates of growth of potential and quasi-potential

output. The estimation results suggest that this decline was attributable to all of the determinants of multifactor productivity: a decline in the growth of the R&D capital stock, a slowing in the trend reduction in the arrival rate of foreigners in the 1980s, and a smaller contribution from the integration of the European Community.

Based on the short-term projections for the Federal Republic presented in International Monetary Fund (1990), the annual rate of growth of potential output is projected to increase from 2 1/4 percent in 1983-88 to 3 percent in 1989-91. This projection reflects higher contributions from both capital and labor inputs and the assumption that the natural rate of unemployment in the FRG will remain relatively stable at about 3 1/2 percent over the 1989-91 period. 1/ The increased contribution of capital and labor inputs from 1989-91 largely reflects the robust investment and increased labor force growth that took place in the period up to mid-1990. 2/

Multifactor productivity growth is not expected to recover from the relatively low rates of growth in the 1980s. Given the strong expansion of actual R&D expenditures in recent years, the contribution of the R&D capital stock to potential output is projected to increase slightly to equal its average contribution to multifactor productivity growth over the 1969-88 sample period. However, this is offset by a somewhat smaller contribution to multifactor productivity growth from the integration of the European Common Market and a continuation of the trend decline of non-German immigration to the FRG.

Actual rates of unemployment are projected to decline by almost 1 1/2 percentage points from end-1988 to 1991 (much of this decline had already occurred by mid-1990), and hence quasi-potential output is projected to grow more rapidly than potential output. The 2 1/2 percentage point gap by which potential output was estimated to have exceeded actual output in 1988 is projected to be reduced to about 1/4 of 1 percentage point by 1991 as actual output growth outpaces the growth of potential output by 3/4 of 1 percentage point per year. And actual output, which was roughly equal to quasi-potential output in 1988, is projected to exceed quasi-potential output by about 1 1/2 percentage points in 1991.

1/ This assumption implies that potential employment would rise in line with labor force growth which is projected to increase to more than 1 percent per year in 1990-91, reflecting, in part, immigration from the GDR and immigration of other ethnic Germans.

2/ As discussed above, the impact on potential output has been attenuated somewhat by the smoothing applied to the determinants of potential output.

V. Summary and Policy Implications

The model and the empirical results presented above have a number of implications for economic policy in the FRG and for the likely impacts of economic and monetary unification with the GDR. The output gaps that were estimated for 1988--2 1/2 percentage points with respect to potential output and zero with respect to quasi-potential output--indicate that there was room for the relatively robust growth and the substantial declines in unemployment that occurred in 1989 and the first half of 1990. The estimation results imply, however, that there would have been some upward pressure on inflation in 1990-91, although this pressure would have been relatively small. 1/

Perhaps the most important implications of the model presented here derive from the distinction between potential output and quasi-potential output. This distinction is based on two empirical results: first, that the natural rate of unemployment, which is empirically determined by structural aspects of the labor market in the FRG, is about 3 1/2 percent compared to actual rates of unemployment of about 6-7 percent; and second, that aggregate wage determination in the FRG is best characterized by a target-real-wage-bargaining model. The gap between potential and quasi-potential output in the period since 1981 is a reflection of high unemployment rates relative to the structurally-determined natural rate of unemployment. As long as unemployment exceeds the natural rate and actual output is below potential output, there is scope to increase employment and output without setting in place an ongoing inflationary process. This suggests that, at least in an environment where economic agents consider macroeconomic policies to be credible and sustainable, some aspects of the constraints on output growth may only be binding in the short run. One such short-run constraint is capital which would normally be expected to respond to actual or expected increases in demand. 2/

Finally, because the model incorporates a relatively rich menu of structural and policy variables that determine the natural rate of

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1/ The upward pressure on inflation in 1989 and 1990 was much less than implied by the estimated growth of potential for 1988 because the robust growth of investment increased productive capacity substantially. In mid-1990, actual output may have exceeded the level of quasi-potential output by about 1 percent implying about 1/4 of 1 percentage point upward pressure on inflation. The 1 percentage point decline in the unemployment rate in the year to mid-1990 implied an increase in the level of real wages relative to productivity growth at potential of about 2 percent. This is consistent with the 1990 wage agreements which suggest some pickup in wage growth.

2/ This is supported by the following quote from the May 1990 business survey reported by the European Economic Community (1990): "Industrial capacity is virtually fully utilized in the member countries. Despite this, the companies questioned are not expecting serious capacity constraints in the near future. The intention is to increase output further."

unemployment and potential output, the empirical results point to areas where government policies can increase the supply responsiveness of the FRG economy. Policies which improve the qualifications of the labor force, reduce the reservation wage, or increase the bargaining power of outsiders in the wage negotiation process can be expected to restrain real wages, increase employment, and lower the natural rate of unemployment. Similarly, structural measures aimed at increasing productivity and flexibility can raise quasi-potential and potential output, both directly and by stimulating investment. Finally, the results also suggest that the completion of the unified European market in 1992 and increased expenditures on research and development may raise total factor productivity and increase the growth of potential output.

APPENDIX

Data Sources and Summary Statistics

The data used in the empirical analysis are quarterly time series for 1968:I to 1988:IV. Except where indicated otherwise, all data are from Statistisches Bundesamt, Volkswirtschaftliche Gesamtrechnungen, Wiesbaden, various issues. Data are seasonally adjusted with the X-11 variant of the Census Method II from the Board of Governors of the Federal Reserve System, except for the series from the Deutsche Bundesbank that were already seasonally adjusted. The variables are defined in Table 1 of the text. Lower case symbols indicate the logarithm of a variable and upper case symbols indicate percent (ratios multiplied by 100).

The price index for exports (p^x) and imports (p^m) of goods and factor services is from Deutsche Bundesbank, Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank, Reihe 4, Frankfurt, various issues. The oil price (p^o) is the U.S. dollar crude oil price multiplied by the DM/U.S. dollar exchange rate (IMF, International Financial Statistics, various issues). Hourly compensation per employee (w) is the log difference of total compensation of employees and total hours worked in the private nonfarm business sector (h); hours worked is the product of employment in the private nonfarm sector and an (economy-wide) index for hours worked per employee which was constructed from Deutsche Bundesbank, op. cit.

The physical capital stock (k) is for the private nonfarm business sector and excludes housing; it was constructed from annual capital stock data interpolated by using cummulated private nonfarm business investment (excluding housing) as the reference series. The physical capital stock of research and development (rd) was constructed from cumulated annual flow data (OECD, Main Science and Technology Indicators, various issues), assuming a constant depreciation rate of 5 percent, and using quarterly private nonfarm investment to interpolate the annual R&D investment series. The initial benchmark was calculated assuming that the growth of R & D investment was equal to the growth of the R & D capital stock in the first period; cf. Goto and Suzuki (1989). Intra-EEC trade as a percent of EEC GNP (EEC) was interpolated from annual data from IMF, Direction of Trade Statistics, various issues.

Data for union density (UNION) were supplied by W. Franz, and was interpolated to a quarterly frequency using the total labor force as a reference series, as was apprentices as a percent of the labor force (APP). The migration data (FOR and NFOR) were supplied directly by Statistisches Bundesamt. DEM was defined as the difference between the actual unemployment rate (U) and an unemployment rate constructed with the age-sex composition of the labor force held constant at the 1968 level based on data from OECD, Labour Force Statistics, various issues. The unemployment insurance replacement ratio (UIRR) is direct government expenditures per unemployed (Arbeitslosengeld and expenditures by the Bundesanstalt für Arbeit; interpolated from annual data using the number of unemployed as the reference series) as a ratio of total compensation per employee.

APPENDIX

Table A1 summarizes the basic characteristics of the data and reports the order of integration of each variable. The t-statistic in the last column is for the lagged value of the "levels" variable in the augmented Dickey-Fuller test for a unit root; for example, if the variable x was I(0), i.e., integrated order of 0, then the t value is for the coefficient γ in the regression: $\Delta x_t = \beta_o + \Sigma_j \beta_j \Delta x_{t-j} + \gamma x_{t-1}$, $j=1,2,\ldots,T$. The critical values are approximately 2.59, 2.90, and 3.54 at the 10, 5, and 1 percent significance level, respectively (see Fuller (1976)). The lag-length T for the augmented Dickey-Fuller test was based on the statistical significance of the maximum lag length for $T \leq 12$. These tests have generally low power, and in some cases the results were inconclusive as indicated by the test statistics in parentheses in the Table. 1/ Some of the ratios appear to be integrated of order higher than zero even though, by definition, they are bounded between 0 and 1, a result which presumably reflects the small sample size.

1/ For wages (w), the t-value for testing I(1) is 4.05 with 1 lag, but only 2.57 with 2 lags in the augmented Dickey-Fuller test. It was concluded that w was probably I(1), and this was supported by test results which indicated that the real product wage (w-p) was I(1). More generally, the conclusions on the integration order also reflect the results of the Sargan-Bhargava Durbin-Watson statistic.

Table A1. Summary Statistics 1/

Variable	Mean	Standard Deviation	Integration Order	Integration t-value
y	12.49	0.13	1	9.93
h	9.79	0.07	1	4.11
k	14.22	0.19	1 (2)	2.75 (8.31)
rd	12.79	0.28	1 (2)	2.08 (9.91)
FOR	1.56	0.35	1	3.29
NFOR	1.05	2.15	1	7.42
EEC	11.39	1.51	1	7.37
U	4.39	2.87	1	3.25
q	2.70	0.19	1	4.58
w	2.00	0.43	1	4.05
NWLC	20.84	2.70	1	11.30
p^c	4.51	0.24	1	3.45
p	4.51	0.25	1	2.89
p^m	4.21	0.30	1	3.89
p^x	4.33	0.24	1	4.29
p^o	3.36	0.83	1	8.44
APP	5.62	0.69	1 (2)	2.79 (4.21)
UNION	32.35	1.48	0	3.01
UIRR	28.38	4.02	0	3.72

1/ Quarterly data, seasonally adjusted for the period 1969:I to 1988:IV (integration tests: 1968:I to 1988:IV).

References

Adams, Charles, and David T. Coe, "A Systems Approach to Estimating the Natural Rate of Unemployment and Potential Output for the United States," Staff Papers, International Monetary Fund (Washington), Vol. 37 (June 1990), pp. 232-93.

Alogoskoufis, George S., and Alan Manning, "On the persistence of unemployment," Economic Policy (October 1988), pp. 428-69.

Baldwin, Richard, "The Growth Effects of 1992," Economic Policy (October 1989), pp. 247-81.

Bean, Charles, "Capital shortages and persistent unemployment," Economic Policy (April 1989), pp. 11-53.

Blanchard, Olivier J., and Stanley Fischer, Lectures on Macroeconomics, MIT Press (1989).

Blanchard, Olivier J., and Lawrence H. Summers, "Hysteresis and the European Unemployment Problem," NBER Macroeconomics Annual, Vol. 1 (1986) and Cross (1988).

Burda, Michael, and Jeffrey Sachs, "Institutional Aspects of High Unemployment in the Federal Republic of Germany," NBER Working Paper No. 2241 (May 1987).

Carruth, Alan A., and Andrew J. Oswald, "On Union Preferences and Labour Market Models: Insiders and Outsiders," The Economic Journal, No. 97 (June 1987), pp. 431-445.

Cochrane, John, H., "How Big is the Random Walk in GNP?" Journal of Political Economy, No. 96 (1988), pp. 893-920.

Coe, David T., "Nominal Wages, the NAIRU and Wage Flexibility," OECD Economic Studies, No. 5 (Autumn 1985), pp. 87-126.

_____, "Hysteresis Effects in Aggregate Wage Equations," in Rod Cross, ed., Unemployment, Hysteresis & the Natural Rate Hypothesis, Basil Blackwell (1988).

_____, "Insider-Outsider Influences on Industry Wages," Empirical Economics, Vol. 15, Issue 2 (1990), pp. 163-84.

Cross, Rod, ed., Unemployment, Hysteresis & the Natural Rate Hypothesis, Basil Blackwell (1988).

Dornbusch, Rudiger, and Stanley Fischer, Macroeconomics, second edition, McGraw Hill (1981).

Engle, Robert F., and C.W.J. Granger, "Co-integration and Error Correction: Representative, Estimation, and Testing," Econometrica (March 1987) pp. 251-76.

_____, and Byung Sam Yoo, "Forecasting and Testing in Co-Integrated Systems," Journal of Econometrics, Vol. 35 (1987), pp. 1-17.

European Economic Community, European Economy, Supplement B, "Business and consumer survey results," No. 5 (May 1990).

Franz, Wolfgang, "Hysteresis, Persistence, and the NAIRU: An Empirical Analysis for the Federal Republic of Germany," in Layard and Calmfors, ed., The Fight Against Unemployment, MIT Press (1987).

Franz, Wolfgang, and Heinz König, "The Nature and Causes of Unemployment in the Federal Republic of Germany since the 1970s: An Empirical Investigation," Economica (Supplement, 1986), pp. S219-44.

_____, and _____, "A Disequilibrium Approach to Unemployment in the Federal Republic of Germany," European Economic Review (May 1990), pp. 413-22.

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

Fuller, Wayne A., Introduction to Statistical Time Series, Wiley (1976).

Gordon, Robert, J., "What is New-Keynesian Economics?" Journal of Economic Literature, Vol. XXVIII, No. 3 (September 1990), pp. 1115-71.

Goto, Akria, and Kazuyuki Suzuki, "R&D Capital, Rate of Return on R&D Investment, and Spillover of R&D in Japanese Manufacturing Industries," Review of Economics and Statistics, Vol LXXI, No. 4 (November 1989), pp. 555-64.

Gottfries, Nils, and Henrik Horn, "Wage formation and the persistence of unemployment," Economic Journal (December 1987), pp. 877-84.

Grilliches, Zvi, "Productivity Puzzles and R&D: Another Nonexplanation," Journal of Economic Perspectives (Fall 1988), pp. 877-84.

Hendry, David F., "Econometric Modelling with Cointegrated Variables: An Overview," Oxford Bulletin of Economics and Statistics, No. 3 (1986), pp. 201-12.

International Monetary Fund, World Economic Outlook (October 1990).

Jaeger A., and M. Parkinson, "Testing for Hysteresis in Unemployment: An Unobserved Components Approach," Empirical Economics, Vol. 15, Issue 2 (1990), pp. 185-98.

Kuh, Edwin, "A Productivity Theory of Wage Levels--An Alternative to the Phillips Curve," Review of Economic Studies, Vol. 34 (1967), pp. 333-60.

Lindbeck, Assar, and Dennis Snower, The Insider-Outsider Theory of Employment and Unemployment, MIT Press (1988).

Lipschitz, Leslie, Jeroen Kremers, Thomas Mayer, and Donogh McDonald, The Federal Republic of Germany, Adjustment in a Surplus Country, Occasional Paper No. 64, International Monetary Fund (1989).

Masson, Paul, and Guy Meredith, "Economic Implications of German Unification for the Federal Republic and the Rest of the World," IMF Working Paper WP/90/85 (September 1990).

McCallum, Bennett T., "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates," Econometrica, Vol. 44, No. 1 (January 1976), pp. 43-52.

Nickell, Stephen, "The Supply Side and Macroeconomic Modeling," in Ralph Bryant, et al., eds., Empirical Macroeconomics for Interdependent Economies, Brookings Institution (1988), pp. 202-21.

Oswald, Andrew J., "The Economic Theory of Trade Unions: An Introductory Survey," Scandinavian Journal of Economics, No. 2 (1985), pp. 160-93.

Sargan, J.D., "Wages and prices in the United Kingdom: a study in econometric methodology," in P.E. Hart, et al., eds., Econometric Analysis for National Economic Planning, Colston Papers, Vol. XVI, London: Butterworth (1964).

Sims, Christopher A., James H. Stock, and Mark W. Watson, "Inference in Linear Time Series Models with some Unit Roots," Econometrica, Vol. 58, No. 1 (January 1990), pp. 113-44.

Solow, Robert M., "Technical change and the aggregate production function," Review of Economics and Statistics, Vol. 39 (1957), pp. 312-20.

Stock, James H. and Mark W. Watson, "Variable Trends in Economic Time Series," Journal of Economic Perspectives (Summer 1988), pp. 147-74.

____, "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," Econometrica, Vol. 55 (1987), pp. 1035-56.

Torres, Raymond, and John P. Martin, "Measuring Potential Output in the Seven Major OECD Countries," OECD Economic Studies, No. 14 (Spring 1990), pp. 127-49.