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WAGE AND PRICE DYNAMICS:  
DIFFERENCES AND COMMON THEMES

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ABSTRACT

The evolution of unemployment in West Germany and the U. S. stands in sharp contrast, with German unemployment much lower from 1960 to the early 1970s but substantially higher from 1984 to 1988. This paper provides a framework for examining the relationship between inflation and unemployment that sheds light on these developments. The theoretical section develops a new nonstructural model of wage and Price adjustment that integrates several concepts that have often been treated separately, including Phillips curve "level effects," hysteresis "change effects," the error-correction mechanism, and the role of changes in labor's share that act as a supply shock.

The empirical analysis reaches two striking conclusions. First, during 1973-90 coefficients in our German wage equations are remarkably similar to those in the U.S., with almost identical estimates of the Phillips curve slope, of the hysteresis effect, and of the NAIRU. The two countries also share similar inflation behavior, in that inflation depends more closely on the capacity utilization rate than on the unemployment rate. The big difference between the two countries is that there is no feedback from wages to prices in Germany, and so high unemployment does not put downward pressure on the inflation rate. During the 1970s and 1980s in Germany there emerged a growing mismatch between the labor market and industrial capacity, so that the unemployment rate consistent with the mean (constant-inflation) utilization rate ("MURU") increased sharply, while in the U. S. the MURU was relatively stable. The German utilization rate in late 1990 was about 90 percent, considerably higher than the estimated MURU of 85 percent. Accordingly, we conclude that the Bundesbank was appropriately concerned about the acceleration of inflation implied by the tight product market of that period.

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## I. INTRODUCTION

### *Persistent Unemployment and Europessimism*

Economic pessimism in Europe has been substantially based on the contrasting evolution of unemployment during the 1980s between Europe and the U. S. While the U. S. unemployment rate fell from over 10 percent in early 1983 to nearly 5 percent in 1988-90, the rate for the EC remained above 10 percent for six straight years (1983-88) and fell only modestly thereafter.<sup>1</sup> The causes of high European unemployment have been posed as a choice between restrictive demand policies and structural impediments at the microeconomic level. Published economic research, so far mainly based on data through the mid 1980s, has as yet reached no consensus on the relative persuasiveness of these two explanations. The economic recovery of several European countries in the late 1980s has generated new data that might break through this stalemate.

Given the new weight of the German economy within Europe, its role as the anchor of the EMS, and the recent controversy created by the anti-inflationary policies pursued by the Bundesbank, it seems natural to choose Germany for a detailed comparative study with the U. S. Following 1960, for almost fifteen years extremely low unemployment rates of about one percent were at the core of the German economic "miracle" and provoked transatlantic envy when contrasted with the average five percent American unemployment rate over the same period. But after 1973 German unemployment rose steadily and exceeded American unemployment during each year between 1984 and 1990. Further, the long-term (one year and

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1. By "commonly used definitions," the EC unemployment rate peaked at 11.0 percent in 1985, and fell below double digits to 9.0 in 1989, 8.4 in 1990, and 8.8 percent in 1991. See *OECD Economic Outlook*, June 1992, Table R19.

longer) component of German unemployment rose markedly relative to the U. S. in the 1970s and 1980s.

### *Phillips Curves, the NAIRU and New Theories of the Labor Market*

Why did German authorities not combat unemployment with a more expansionary monetary and fiscal policy? A common method to evaluate the scope for demand expansion is to compare the actual unemployment rate with the "non-accelerating inflation rate of unemployment," the infamous NAIRU. Since the technology for calculating the NAIRU requires an estimated relation between inflation and the unemployment rate, the policy implications of the NAIRU are inextricably linked to dynamic Phillips curve equations for price and wage changes.

As usual, new economic events (in this case high European unemployment) have generated new economic ideas. In Europe, the apparent increase in the NAIRU spawned the hysteresis interpretation: the NAIRU is not a number fixed by a given set of microeconomic distortions, but rather tags along in the wake of the actual unemployment rate, as in the famous American song "Me and my Shadow." Hysteresis is a mechanical hypothesis, positing in the limit that inflation depends on the *rate of change* of unemployment and not (as in the standard Phillips curve) on the *level* of unemployment. But hysteresis needs an underlying economic explanation, for which the leading proposed candidate is the insider-outsider theory, which stresses the disenfranchisement of the long-term unemployed from the wage-setting process.

*Plan of the Paper*

We employ a common theoretical framework and a set of comparable data to investigate similarities and differences in wage and price dynamics in Germany and the U. S. The point of departure is a set of nonstructural reduced forms that identify broad differences in behavior without restrictions tied to particular theories. Particular attention is paid to the related nonstructural concepts of cointegration and error correction. The second step is to examine structural tests that have been proposed by developers of specific theories and to determine whether key parameters suggested by these theories can be identified.

The paper begins in Part II with an examination of the facts and the puzzles that they suggest for further analysis. Part III begins the theoretical treatment with a nonstructural analysis of the interplay between wage and price dynamics, cointegration and error correction, changes in labor's share, the NAIRU, supply-shift variables, and hysteresis. Then in Part IV the theoretical analysis turns to structural models, starting with a traditional Phillips curve model that allows changes in relative prices and tax rates to influence wage behavior, and then proceeding to the identification of structural hypotheses like the insider-outsider model and real-wage bargaining model. Part V contains the empirical estimates of parameters in the wage and price equations and performs dynamic simulations that identify the NAIRU in both countries. Part VI draws the results together and concludes.

## II. SOME FACTS AND PUZZLES

### *The Time Path of the Unemployment Rate*

Figure 1 and the first two columns of Table 1 display the evolution of the unemployment rate in the United States and Germany. While the unemployment rate in the United States declined from about five percent in the early 1960s to 3.5 percent in 1968-69, Germany experienced virtually no unemployment until 1973. During 1960 to 1972 the average unemployment rate was below 1.0 percent in every year but the recession period of 1967-68, when the rate increased only to 1.8 percent. The German labor market was characterized by excess demand which was partly accommodated through the employment of "guest-workers," i.e., foreign workers, which increased from 1.3 percent to 10 percent of total employment between 1960 and 1973.

The spurt in the German unemployment rate began in 1974. While unemployment in the United States evolved more cyclically, with peaks in 1975 and 1982-83, Germany experienced a rise in unemployment in two steps, roughly in the same years, but with little decline between 1975-1980 and 1983-1988. During 1983-90 the German unemployment rate was above that in the U. S., which would not have been so remarkable except for the stark contrast in the opposite direction during the 1960s and 1970s.

Table 1 shows also the high and growing share of long-term unemployment in Germany, compared to its small share in the U. S. There has been a sharp contrast between negligible growth in German employment and huge American growth (76 percent between the

first and last period). As well, annual hours per employee in Germany have fallen from 16 percent above the U. S. level to 2 percent below.

### *NAIRU: Alternative Estimates and Concepts*

The two countries differ not only with respect to the development of actual unemployment but also with respect to the time pattern of the natural rate. According to Gordon (1990), the U.S. natural rate was roughly stable at about 6.0 percent throughout the period 1975-90, having gradually risen from 5.2 to 6.0 percent during the two decades before 1975. Estimates of the NAIRU for Germany are much more controversial. While most authors estimate a NAIRU of some 2 percent at the beginning of the 1970s [Coe (1985), Franz (1987)], the range of NAIRU estimates in the second half of the 1980s is between 5.5 percent [Franz and Hofmann (1990)] and nine percent [Funke (1991)]. Common to all studies is, however, the much more substantial increase of the NAIRU in Germany than in the U. S.

As we shall see below, one explanation for the divergence of German NAIRU estimates is the failure to distinguish alternative NAIRU concepts, particularly the distinction between a NAIRU calculated alternatively holding constant or ignoring the effects of supply shocks, and alternatively incorporating or ignoring the effects of hysteresis. The failure to distinguish alternative NAIRU concepts helps to explain the range in NAIRU estimates for Germany and for the eighties mentioned above: tentative estimates for 1986 wind up with a contemporaneous and steady-state NAIRU of 8.8 and 5.7 percent, respectively [Franz (1987)]. Given the evolution of additional data since this and other studies, it may be possible now to provide a narrower band of estimates of the German NAIRU.

*Alternative Theories*

Table 2 displays data on wage and price changes, productivity growth, and the rate of capacity utilization (displayed as the deviation from the 1960-90 mean rate). Wage and price changes in the U. S. decelerated markedly in the second half of the 1980s despite higher capacity utilization than in the first half, which may be explained by lagged wage and price adjustment to earlier low utilization, as well as by lower oil prices. The figures for Germany in the eighties show relatively low and stable wage and price inflation with relatively high capacity utilization. Given the persistently high unemployment rate, the time pattern of those variables cannot be explained by the standard Phillips curve model unless it is claimed that the actual unemployment rate coincided with the NAIRU.

If hysteresis is present in fact, this calls for a theoretical explanation.<sup>2</sup> The insider-outsider model of wage determination shows how employed insiders are able to convert a favorable demand or supply shock into wage increases for themselves rather than into new jobs for the unemployed. The target real-wage bargaining model goes in the same direction. In addition to total unemployment in the Phillips curve approach, nominal wage increases are influenced in addition by the deviation of real wages or of labor's income share from target levels. If the target level of labor's share responds hysteresis-like to its actual level, then any pressure on wages stemming from deviations of the actual share from the target share gradually disappears.

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2. A wide variety of theoretical and empirical papers on hysteresis is found in Cross (1988).



### *Interpreting Changes in Labor's Share*

Standard neoclassical theory emphasizes that the equilibrium level of labor's share is determined largely by the elasticity of output to changes in labor input, leading one to expect that the actual labor share would fluctuate around its equilibrium level. In contrast, the hypothesis that Europe suffered from classical unemployment in the 1980s was based on a disequilibrium hypothesis that the real wage was boosted artificially above labor productivity, resulting in an increase in labor's income share (see Schultze, 1987). The first two columns in Table 3 display gross labor compensation as a share of national income and indicate the reverse of the pattern that one might expect.<sup>3</sup> The German labor share has fluctuated around its mean of 67.8 percent but shows no trend, i.e., it is roughly equal to its mean in both 1961-64 and 1985-90. In contrast the U. S. labor share exhibits a one-time jump in the early 1970s, with little movement in other periods. Given the widespread characterization of the German labor movement as strong and the American as weak, it is clearly surprising to find that the German labor share declined much more in the late 1980s than did the American.

In contrast to the data in columns 1 and 2, copied directly from the National Income Accounts (NIA), columns 3 and 4 show an alternative labor's share concept implied by the set of wage, price, and productivity data entered into our estimated wage and price equations. One can cumulate changes in the real product wage minus average labor productivity and

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3. A qualification to the labor share data in Table 3 is that no attempt is made to allocate self-employment ("proprietors'") income among labor and capital. One attempt to do so (Gordon, 1977b) concludes that such adjustments create a secular downward adjustment in the German labor share relative to the U. S. labor share, thus accentuating the contrast already evident in Table 3.

convert them into an "Adjusted Labor Share Index," with the *level* of the adjusted share set to equal the NIA share in 1987. Since different data are used to construct the adjusted share, e.g., for the nonfarm private sector rather than the total economy, data differences can create a difference between the NIA and adjusted share measures.

Fortunately, a comparison of the share concepts shows a reasonably consistent picture. The adjusted German share peaks in the late 1970s rather than the early 1980s for the NIA concept, and the adjusted share in the late 1980s is distinctly lower than in any earlier period. For the U. S. the adjusted share rises steadily from the late 1960s to the early 1980s, in contrast to the one-shot jump for the NIA share in the early 1970s.

In addition to the disequilibrium real wage hypothesis, there are several other reasons why the equilibrium level of labor's share may not be determined solely by competitive factor pricing given a particular production function. The wedge between the before-tax product wage and the after-tax consumption wage may play a role. Table 3 decomposes the total wedge into that portion due to changes in the ratio of consumer prices to product prices (the "price wedge") and the remaining portion due to changes in taxes (the "tax wedge"). The German price wedge, expressed on a 1987 base, shows a sharp downward jump in the early 1970s as a result of the appreciation of the DM during the transition from the Bretton Woods regime to the flexible exchange rate regime. In addition the upward bulge in the German price wedge in the late 1970s and early 1980s reflects higher oil prices. The behavior of the U. S. price wedge reflects both the decline in the dollar and fluctuations in oil prices; the increase in the late 1980s indicates that the sharp post-1985 decline in the dollar more than offset the

benefit of lower oil prices. The tax wedge shows a monotonic upward trend for both countries, but at about triple the rate in Germany as in the U. S.

### III. WAGE-PRICE DYNAMICS AND LABOR'S SHARE: A NON-STRUCTURAL APPROACH

Our theoretical treatment integrates the traditional literature on the Phillips curve and hysteresis with the more recent attention to cointegration and error-correction. We distinguish between separate wage and price equations, thus allowing us to incorporate dynamic feedback between wages and prices, and the possibility that the NAIRU emerging from the wage equation is not the same as the NAIRU which matters for monetary policy, i.e., that which emerges from the price equation.

#### *Price and Wage Equations*

A general specification relates current and lagged price changes ( $p$ ) to current and lagged wage changes ( $w$ ), an index of excess demand ( $X$ , normalized so that  $X=0$  indicates the absence of excess demand), a vector of other relevant variables ( $z$ ), and a serially uncorrelated error term ( $e$ ):

$$a(L)p_t = b(L)w_t + g(L)X_t + d(L)z_t + e_t. \quad (1)$$

In our notation upper-case letters designate logarithms of levels and lower-case letters designate

first differences of logarithms. The vector  $z_t$  includes "supply shift" variables that can alter the rate of inflation at a given level of excess demand, e.g., changes in the "price wedge" or "tax wedge." All components of  $z_t$  are expressed as first differences and normalized so that a zero value indicates an absence of upward or downward pressure on the inflation rate. Except for its distinction between growth rates and log levels, required to define the "natural rate" of the excess demand variable  $X_t$ , (1) is a general form that can encompass nonstructural VAR models or, with restrictions, can be made to resemble traditional "structural" price and wage equations.<sup>4</sup>

The coefficients  $a(L)$ ,  $b(L)$ ,  $g(L)$ , and  $d(L)$  are polynomials in the lag operator  $L$ , and  $a(L)$  can be normalized so that its first element equals unity.<sup>5</sup> With this normalization, the term  $a(L)p_t$  can be rewritten as:

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4. Note that the entry of the level of  $X_t$  does not require that a "level demand effect" be present; if the estimated coefficients display an alternation of a positive contemporaneous coefficient and negative lagged coefficient (with all coefficients summing to zero), this would indicate the presence of a "rate of change demand effect" and would be compatible with what we define below as "full hysteresis." Symmetrically, as we shall see below, the inclusion of an error-correction term allows an expression specified in first differences to recover a relationship between the levels (rather than first differences) of two variables.

5. The analysis in this section is adapted for this paper from Gordon (1990). Up to this point, the notation and normalization follow Blanchard (1987), except for the distinction here between demand and supply variables and the interpretation of the demand variable as a level rather than a first difference.

$$a(L)p_t = p_t + a'(L)p_{t-1}. \quad (2a)$$

Similarly,

$$b(L)w_t = b_0 w_t + b'(L)w_{t-1}. \quad (2b)$$

Substituting (2a) and (2b) into (1), we have a more transparent version of the price change equation:

$$p_t = -a'(L)p_{t-1} + b_0 w_t + b'(L)w_{t-1} + g(L)X_t + d(L)z_t + e_t. \quad (3)$$

Here we see that the price equation includes not just lagged values of price and wage change, but also the current value of wage change.

What about the wage equation? The price equation (3) has the startling implication *that there is no such thing as a separate wage equation*. Equation (3) is a price and wage equation at the same time, which can be seen when (3) is renormalized as:

$$w_t = -\left(\frac{1}{b_0}\right) [b'(L)w_{t-1} - p_t - a'(L)p_{t-1} + g(L)X_t + d(L)z_t + e_t]. \quad (4)$$

Thus, without further restrictions, the "price equation" (3) and the "wage equation" (4) are

alternative "rotations" of the same equation.<sup>6</sup>

Two main approaches are available to identify separate price and wage equations. First, different sets of  $X_t$  and  $z_t$  variables could be assumed to enter the price and wage equations. However, this is implausible *a priori*, since any variable relevant as a determinant of price change may also be relevant for participants in the wage-setting process, and vice-versa for prices.

A second approach is to restrict the contemporaneous coefficient on  $w_t$  in the price equation or on  $p_t$  in the wage equation, since it is likely that there is a contemporaneous correlation between  $w_t$  and the error term  $e_t$  in (3), or similarly for  $p_t$  in (4).<sup>7</sup> Some past papers have set the contemporaneous coefficient to a particular value or to zero in one of the two equations; in this paper the price and wage equations are placed on an equal footing by excluding the contemporaneous wage and price terms from both equations:

$$p_t = a^p(L)p_{t-1} + b^p(L)(w-\theta)_{t-1} + g^p(L)X_t + d^p(L)z_t + e_t^p. \quad (5)$$

$$(w-\theta)_t = b^w(L)(w-\theta)_{t-1} + a^w(L)p_{t-1} + g^w(L)X_t + d^w(L)z_t + e_t^w. \quad (6)$$

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6. This insight and the term "rotation" come from Sims' comment on Blanchard (1987).

7. Some papers in this literature cite Kuh (1967), who proposed a "productivity theory of wage levels," that is, that the change in the wage rate was explained by a distributed lag of changes in productivity, and hence that the level of the wage was related to the level of productivity. However, a modern rereading of Kuh reveals that his econometric investigation is plagued by simultaneity, with the current value of both the consumer price index and the current output deflator entered as explanatory variables for the current wage rate (pp. 347, 350).

The first bit of structure is imposed here by replacing the wage change in (3) and (4) by the wage change minus the change in labor's average product ( $w-\theta$ ), that is, the change in nominal unit labor cost. Two very different rates of wage change would be consistent with the same inflation rate if they were offset by a difference in productivity growth by the same amount.

### *Interpreting Changes in Labor's Share*

Implicit in (5) and (6) is a relationship between inflation and changes in labor's share, since the change in labor's share ( $s_t$ ) is defined as:

$$s_t = w_t - \theta_t - p_t. \tag{7}$$

The effects of changes in labor's share in the inflation equation become transparent if (5) is rewritten in the following form, adding and subtracting  $b^p(L)p_{t-1}$  and using the definition (7):

$$p_t = [a^p(L) + b^p(L)]p_{t-1} + b^p(L)s_{t-1} + g^p(L)X_t + d^p(L)z_t + e_t^p. \tag{8}$$

Similarly, for labor cost, we have:

$$(w-\theta)_t = [a^w(L) + b^w(L)](w-\theta)_{t-1} - a^w(L)s_{t-1} + g^w(L)X_t + d^w(L)z_t + e_t^w. \tag{9}$$

The effect of a change in labor's share on inflation depends on the sum of coefficients ( $\Sigma b^p_i$ )

in (8). If that sum is a positive fraction between zero and unity, then an increase in labor's income share becomes a source of "cost push" that is on an equal footing with any other type of adverse supply shock. If that sum is zero, then wage changes are irrelevant for inflation, meaning that the counterpart of an increase in labor's share is a profit squeeze rather than upward pressure on the inflation rate. This would imply a dichotomy between the time series processes determining inflation rate and wage changes; wage behavior would be irrelevant in determining the inflation rate and the natural rate of unemployment, and the wage equation would be of interest only for its description of changes in the distribution of income.

### *Cointegration and Error Correction*

The previous exposition of dynamic adjustment expresses the price and labor cost variables only in first differences, allowing only a single "level" variable, excess demand ( $X$ ) to represent a disequilibrium that may lead to wage and price adjustment. However, there is a long literature going back to Phillips (1957) and Sargan (1964) that allows for "error correction," in this context the deviation of the real wage from some normal or equilibrium level is allowed to enter as a separate measure of disequilibrium in an equation relating wage changes to price changes or vice versa. For instance, an increase in the real wage caused by "wage push" (as happened in some European countries in the late 1960s), or a decrease in the real wage caused by an oil shock (as happened in the U. S. in the mid 1970s) may have created pressure for adjustment in both wages and prices independently of the evolution of the excess



demand variable, e.g., the unemployment rate.<sup>8</sup>

More recently, the concept of error correction has been linked to that of cointegration, which can be defined informally as the notion that a linear combination of two series, say the price level and unit labor cost, is stationary.<sup>9</sup> When two such variables are cointegrated, a regression consisting entirely of differenced data will be misspecified and a regression consisting entirely of level data will omit important constraints. The solution is to estimate a regression of the first difference of one variable on the first difference of the other, plus an error correction variable consisting of the lagged log ratio of one variable to the other.<sup>10</sup> Omitting the lag operators to simplify, an error correction version of (8) and (9) is:

$$p_t = (a^p + b^p)p_{t-1} + b^p s_{t-1} + c^p (S - S^*)_{t-1} + g^p X_t + d^p z_t + e_t^p, \quad (10)$$

where  $S_t = W_t \theta_t P_t$  is the log level of labor's share and  $S^*$  is the equilibrium log level of labor's share. Thus the error correction term generates an increase in the rate of price change whenever labor's share exceeds its equilibrium level, and similarly a decrease in the rate of change of labor cost:

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8. The basic theoretical reference on error-correction is Hendry-Pagan-Sargan (1984) and the references contained therein. The relationship between error-correction and cointegration is explored in Engle-Granger (1987).

9. For the formal definition of stationarity and co-integration, see Engle-Granger (1987), pp. 252-3.

10. A complete taxonomy of the possible forms of dynamic specification in a bivariate model are presented in Hendry-Pagan-Sargan (1984), pp. 1040-49. A simple exposition in the context of the demand for money is contained in Gordon (1984), pp. 419-23.

$$(w-\theta)_t = (a^w + b^w)(w-\theta)_{t-1} - a^w s_{t-1} - c^w(S-S^*)_{t-1} + g^w X_t + d^w z_t + e_t^w. \quad (11)$$

When the relation between cointegration and error correction is recognized, then a two-step procedure is indicated. First, the price and labor cost variables must be tested empirically for cointegration. If they are indeed cointegrated, then the specification must follow the error-correction format of (10) and (11) rather than the simple first-difference format of (8) and (9).<sup>11</sup>

### *The NAIRU and "Hysteresis"*

A simplified version of equation (10) illustrates alternative definitions of the NAIRU. We restrict the coefficient on lagged inflation to unity; include only a single lagged labor's share term ( $s_{t-1}$ ) and a single supply shock term ( $z_t$ ) and proxy the excess demand term by a constant and the current unemployment rate ( $U_t$ ):

$$p_t - p_{t-1} = g_0 - g_1 U_t + d_1 s_{t-1} + d_2 (S-S^*)_{t-1} + d_3 z_t + e_t. \quad (12)$$

Using (12), we can define the "shock" NAIRU ( $U^s$ ) as that which is consistent with steady inflation ( $p_t = p_{t-1}$ ) and includes the higher level of unemployment needed to offset any upward push on inflation coming from the labor's share, error-correction, and supply shock terms in (10), but omits the error term, which is assumed to be serially uncorrelated with mean zero:

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11. We are grateful to our discussant Michael Funke and to Mark Watson for stressing the imperative of the error-correction specification in this context.

$$U_t^S = \frac{g_0 + d_1 s_{t-1} + d_2 (S-S^*)_{t-1} + d_3 z_t}{g_1} \quad (13)$$

The "no shock" NAIRU ( $U_t^{NS}$ ) is the concept that "controls" for the influence of changes in labor's share, the error-correction term, and supply shocks:

$$U_t^{NS} = \frac{g_0}{g_1} \quad (14)$$

Policy discussions are not always clear regarding the concept of the NAIRU that is relevant for policymaking. To keep inflation from responding at all to an increase in labor's share or an adverse supply shock, policymakers must apply an "extinguishing" policy contraction that raises the unemployment rate from the "no shock" NAIRU in (14) to the "shock" NAIRU in (13).<sup>12</sup>

Hysteresis as applied in this context represents the hypothesis that the no-shock NAIRU responds fully or partially to the lagged actual unemployment rate:

$$U_t^{NS} = U_t^* + \phi(U_{t-1} - U_t^*) \quad (15)$$

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12. Gramlich (1979) introduced the distinction between accommodative, neutral, and extinguishing responses to supply shocks. An extinguishing response attempts to set the actual unemployment rate equal to the "shock" NAIRU.

$U_t^{NS}$  is the "quasi-equilibrium" or "contemporaneous" NAIRU which is conditional on the history of unemployment, and  $U_t^*$  is the "steady state" NAIRU, i.e. the NAIRU sustainable in the long-run equilibrium. When (14) and (15) are substituted into the simplified Phillips curve (12), we have:

$$p_t - p_{t-1} = g_1[U_t^* + \phi(U_{t-1} - U_t^*) - U_t] + d_1s_{t-1} + d_2(S-S^*)_{t-1} + d_3z_t + e_t. \quad (16)$$

Rearranging, we see that the change in the inflation rate now depends on the steady-state NAIRU, the lagged *level* of the unemployment rate, and the current *change* in the unemployment rate:

$$p_t - p_{t-1} = -g_1[(1-\phi)(U_t - U_t^*) - \phi\Delta U_t] + d_1s_{t-1} + d_2(S-S^*)_{t-1} + d_3z_t + e_t. \quad (17)$$

Three cases are of interest.

- **Full Hysteresis.** If  $\phi=1$ , then the "level effect" vanishes and the change of inflation depends only on the change in unemployment and the additional terms in (17).
- **No Hysteresis.** If  $\phi=0$ , then the change term drops out, and (17) becomes identical to (12), with  $U^* = g_0/g_1$ . This is the case of the pure "level" or "Phillips curve" mechanism.
- **Intermediate case: persistence.** If  $0 < \phi < 1$  we have the intermediate "persistence" case, in which both the level and rate of change effects matter, and

in which the contemporaneous NAIRU can drift away from the steady state NAIRU.

To estimate the parameters of interest and determine which case is consistent with the data, we can run the following regression:

$$p_t - p_{t-1} = h_0 - h_1 U_t - h_2 \Delta U_t + d_1 s_{t-1} + d_2 (S-S^*)_{t-1} + d_3 z_t + e_t. \quad (18)$$

The parameters to be identified are the hysteresis coefficient ( $\phi$ ), the coefficient of response of the inflation rate to unemployment ( $g_1$ ), and the "steady state" NAIRU ( $U^*$ ). These can be computed from the estimated coefficients in (18) as:

$$\phi = \frac{h_2}{h_1 + h_2}; \quad g_1 = h_1 + h_2; \quad U^* = \frac{h_0}{h_1}. \quad (19)$$

The interpretation of these is straightforward; note that  $U^*$  cannot be defined when there is no level effect ( $h_1=0$ ), since in this case the NAIRU freely floats in response to the past behavior of actual unemployment. If there is a level effect and  $U^*$  can be identified, the determinants of  $U^*$  are assumed to be "microeconomic structure" and are not explained.

#### IV. STRUCTURAL INTERPRETATIONS OF WAGE BEHAVIOR

Thus far we have presented nonstructural price and wage equations which contain only lagged prices and wages, an error-correction term, a demand term (e.g., the level and/or change

of the unemployment rate), and an unspecified "supply shift" term. We turn now to a structural wage equation that allows us (1) to specify the form of the supply shift variable; (2) to contrast the previous nonstructural equations with the traditional "expectational Phillips curve" approach; and (3) to specify forms of the insider-outsider and real-wage bargaining models that are suitable for testing.

### *How the Price and Tax Wedge Enter the Phillips Curve*

The Phillips curve hypothesis is based on the idea that wages adjust to eliminate any excess demand or supply in the labor market.<sup>13</sup> The demand for labor is determined by setting the expected real before-tax wage equal to the marginal product of labor and solving for the quantity of labor as a function of the expected real before-tax wage. With a Cobb-Douglas production function (written in logs as  $Y = \Theta + \gamma N$ , where  $\Theta$  is the productivity shift factor and  $N$  is labor input), the demand for labor is:

$$N^d = \alpha (\gamma + \theta + P^e + T^i - W - T^f). \quad (20)$$

Here  $\alpha$  is  $1/(1-\gamma)$ , the elasticity of labor demand with respect to the (inverse of the) real wage,  $P^e$  is the expected product price,  $T^i$  is the indirect or value-added tax factor, and  $T^f$  is the

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13. The particular formulation set out here dates back to Gordon (1977) and earlier authors, including Lipsey and Parkin.

employer-paid payroll tax factor.<sup>14</sup> Labor supply is:

$$N^s = \beta(W + T^p - R - C^e), \quad (21)$$

where  $T^p$  is the personal tax factor (including both personal income taxes and the employee portion of the payroll tax),  $R$  is the "aspiration real wage" that governs labor supply, and  $C^e$  is the expected consumption price deflator.

Using  $X$  as before to represent excess demand, we can define the log level ( $X$ ) and rate of change ( $x$ ) of excess demand as:

$$X = N^d - N^s; \quad x = n^d - n^s. \quad (22)$$

The Phillips curve hypothesis is that the excess demand for labor is eliminated at a rate which is proportional to its own level, i.e.:

$$x = -gX, \quad (23)$$

When we take the time derivative of the difference between the labor demand and supply functions in (20) and (21), we obtain an expression for the change in excess demand, which in

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14.  $T^i = 1 - \tau^i$  and  $T^p = 1 + \tau^p$ , where  $\tau$  represents the appropriate tax rate.

turn can be substituted into the adjustment equation (23). When solved for  $w-\theta$ , this directly yields the "expectational Phillips curve" wage equation:

$$w - \theta = p^e + \frac{1}{\alpha + \beta} [\beta(r - \theta + c^e - p^e - t^p) + \alpha(t^i - t^f) + gX] \quad (24)$$

In equilibrium, labor demand equals labor supply and tax rates remain unchanged, hence  $t^p = t^i = t^f = X = 0$ . If the reservation wage rate increases at the same rate as the productivity shift term ( $r=\theta$ ) and  $c^e = p^e$ , then  $w - \theta = p^e$ , i.e. the growth rate of nominal unit labor cost equals the inflation rate of output prices. Under these conditions, in equilibrium labor's income share is constant. A general expression for the equilibrium level of labor's share,  $S^*$ , can be obtained by setting (20) equal to (21) and solving:

$$S^* = \frac{1}{\alpha + \beta} [\alpha\gamma + \beta(R - \Theta + C - P - T^p) + \alpha(T^i - T^f)]. \quad (25)$$

From (25) it is clear that the equilibrium labor share becomes a constant  $[\alpha\gamma/(\alpha+\beta)]$  if  $R=\Theta$ , the product price and consumption price indexes are identical, and if there are no taxes. For small values of the real wage elasticity of labor supply,  $\beta$ , labor's share equals  $\gamma$ , the exponent on labor in the production function.

### *Estimated Form of the Wage Equation*

Part III developed a nonstructural wage equation (11) which made the rate of change of unit labor cost depend on its own lagged values, lagged changes of labor's share, an error-



correction term (the deviation of labor's share from its equilibrium value), current and lagged values of an unspecified excess demand variable ( $X$ ), and current and lagged changes in an unspecified supply shift variable ( $z$ ). Our discussion of hysteresis suggested that the excess demand variable could be proxied by a constant, the level of unemployment, and the change in unemployment, as in equation (18). Our structural Phillips curve model suggests that the rate of change of the price wedge and tax wedge, appropriately defined, are the appropriate supply shift variables, as in (24). Taken together, the wage equation becomes:

$$\begin{aligned} (w-\theta)_t = & [a^w(L) + b^w(L)](w-\theta)_{t-1} - a^w(L)s_{t-1} - c^w(S-S^*)_{t-1} \\ & + h_0^w - h_1^w U_t - h_2^w \Delta U_t + d_1^w(L)\pi_t + d_2^w(L)\omega_t + e_t^w. \end{aligned} \quad (26)$$

Here  $\pi_t$  and  $\omega_t$  are, respectively, the rates of change of the price wedge and tax wedge.

### *Alternative hypotheses*

**Insider-Outsider.** Long-term unemployed persons may not exert a strong influence on wage determination, if any at all. This view rests on the hypothesis that long-term unemployed persons are imperfect candidates for filling vacancies. Their human capital and work attitudes may have deteriorated during their extended spell of unemployment, or they may suffer from discrimination, based on false beliefs about the deterioration of their skills. To allow for this approach, we define the "true" unemployment variable ( $U'$ ) that enters equation (26) as

equation (26) as

$$U_t = U_t^S + \psi U_t^L. \quad (27)$$

This formulation introduces a parameter ( $\psi$ ) to indicate the extent to which the long-term unemployed are perfect substitutes for the short-term unemployed, which requires ( $\psi=1$ ). When the "true" unemployment concept defined in (27) is substituted into (26), the weight on long-term unemployment may be calculated. This provides a test of the insider-outsider model.

**Real-wage bargaining model.** As formulated by Coe and Krueger (1990), who in turn attribute the idea to Sargan (1964), the real wage bargaining model involves introducing an error-correction term into the wage equation, which we have already carried out above. To understand this interpretation, we can refer to a simple version of equation (11) above:

$$(w - \theta)_t = p_t^e - g_1(U - U^*)_t - g_3(S - S^*)_{t-1}, \quad (28)$$

where as above  $S = W \cdot P \cdot \Theta$ , the log level of labor's share. When  $g_3=0$ , this is a stripped-down expectational Phillips curve relating the growth rate of unit labor cost to the level of the gap between actual and natural unemployment. In contrast, when  $g_3 > 0$  the equation is converted from a growth rate relationship to a level relationship among the same variables. This is evident in the long run version of (28) in levels that assumes  $p = p^e$ :

$$S = S^* - \left( \frac{g_1}{g_3} \right) (U - U^*). \quad (29)$$

The target real wage model implies that the target level of labor's share (the left-hand side of (27)) is equal to the equilibrium level ( $S^*$ ) adjusted for the effect of the unemployment gap, which "can be thought of as a proxy for the bargaining power of labor" (Coe-Krueger, p. 6). In contrast to the Phillips curve model of (28) with  $g_1=0$ , which can be in long-run equilibrium only with unemployment at the natural rate, the economy in (29) can be in a long-run "quasi-equilibrium" as long as the real wage relative to trend productivity has been pulled down below  $S^*$  by a level of unemployment held above the natural rate.

In this approach, since the *level* of real wages is related to the *level* of unemployment, the *growth* of real wages is related to *changes* in unemployment. This might appear to make the real wage bargaining model observationally equivalent to the full hysteresis approach developed above. However, full hysteresis requires that the "level" effect of unemployment be absent, i.e., that  $g_1=0$  in (28) and (29). Thus if  $g_1>0$  it is possible that the real-wage bargaining model could be validated even if there is no hysteresis, full or partial. Just as hysteresis is a hypothesis that provides a structural interpretation for the entry of a term in the change of the unemployment rate, so the real-wage bargaining hypothesis provides a structural interpretation of the error-correction term that should enter any equation relating two cointegrated series.

*Estimated Form of the Price Equation*

The price equation is estimated in the same format as the wage equation (26), with the rate of change of an aggregate price index ( $p$ ) replacing the rate of change of unit labor cost ( $w$ ). While in principle the same variables that matter for the wage equation could matter for the price equation, in practice there are differences. Because price changes are determined in the product market rather than the labor market, we replace the unemployment rate with two alternative demand variables, (1) the log output ratio (i.e., detrended output), and (2) the capacity utilization rate. Also, a different set of supply shift variables may enter the price equation, particularly changes in the relative prices of oil and/or imported materials. Since expectations of price setters are influenced by the variables that enter the wage equation and vice versa, in principle all supply shift variables relevant for either equation should enter into both. In practice there are insufficient degrees of freedom for everything to be included, particularly when lagged effects are present, and so we experiment to find the best set of supply shift variables for each equation in each country, starting from a set that includes the change in the tax and price wedges, as in (26), and changes in the relative prices of imports, imported materials, energy, and in the real exchange rate (the initial list of candidates differs slightly between Germany and the U. S., reflecting data availability).

## V. ESTIMATED WAGE AND PRICE EQUATIONS

### *Data and Lag Lengths*

The basic format for wage change is equation (26) and for price change (26) with the price and labor cost variables interchanged as in (10) and (11). Equations are estimated on quarterly data with sample periods ending in 1990:4 and beginning at the earliest possible date consistent with the 1960:1 starting date of the German data, allowing for lag lengths. The data sources for the wage, price, productivity, price wedge, and tax wedge variables are listed in the notes to Tables 2 and 3 above. All quarterly change variables are defined in percent at annual rates, that is, as the first difference of the log times 400. All U. S. variables are seasonally adjusted by official agencies; most of our German data contain strong seasonal patterns that we correct prior to running the regressions.<sup>15</sup>

- **Change in labor cost ( $w\cdot\theta$ ).** The wage is gross of payroll taxes. Following Gordon (1971) and subsequent papers, the productivity variable relevant for wage and price setting is a weighted average of a spline trend and the deviation of actual productivity from that trend, or in our notation for rates of change,  $\theta' = \theta^* + \eta(\theta - \theta^*)$ . By defining the wage change variable in the form of  $w\cdot\theta^*$  and entering  $(\theta - \theta^*)$  as a separate variable, the parameter  $\eta$  can be estimated freely (rather than imposed, as in many studies).<sup>16</sup>

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15. Seasonal adjustment is carried out in the RATS regression program using the option of "trend exponential smoothing."

16. The benchmark dates for the spline productivity trend are for Germany 1960:1, 1970:1, 1979:1, and 1990:4. For the U. S. they are the same as in Gordon (1990), 1954:2, 1964:3, 1972:1, 1978:4, 1986:4, and the additional date 1990:4.

- **Change in price ( $p$ ).** The product price is represented by the GDP deflator, implicit for Germany and fixed-weight for the U. S. The price wedge is the ratio of the consumption deflator to the same product price term (again, implicit for Germany and fixed-weight for the U. S.).
- **Excess demand variable.** The unemployment rate is the demand variable entering into the wage equations. Outsider ineffectiveness is assessed by splitting the total unemployment rate into the long-term ( $U^L$ ) and residual ( $U^R$ ) components and estimating the weight ( $\psi$ ) attributable to long-term unemployment as in (27) above. For the price equations two alternative demand variables are used, the log output ratio and the rate of capacity utilization. The log output ratio for Germany is the deviation from a spline trend running through 1960, 1972, 1979, and 1990, and for the U. S. uses particular quarters in the years 1957, 1963, 1972, 1979, 1987, and 1990 (Gordon, 1990). For both countries the capacity utilization rate is entered as the deviation from the 1960-90 mean of that series (as displayed in Table 3 above).
- **Tax wedge.** The tax wedge is the ratio of gross-of-tax employer labor cost to net-of-tax employee take-home pay. Specific definitions for the two countries are provided in the notes to Table 3.
- **Lag lengths.** In recent work Gordon (1990) found that very long lag lengths of up to 24 quarters were required in estimating equations like (26) for the U. S. Most previous work on Germany has used much shorter lag lengths, and in one extreme case

lag lengths are restricted to a single quarter.<sup>17</sup> The algebra in (8) and (9) that replaces lagged prices and labor cost by the change in labor's share requires identical lag lengths on the lagged dependent variable and on the lagged change in labor's share. Lag lengths for these two variables in the estimated equations are chosen by starting with long lags and then truncating the length of the distribution, based on formal exclusion tests. This procedure chooses lag lengths for the lagged dependent variable and the change in labor's share of 4 quarters for Germany and 12 quarters for the U. S. Lag lengths are chosen for other variables by estimating initially with a four-quarter length and then truncating insignificant terms.<sup>18</sup>

- **Cointegration and Error-correction.** Before estimating wage and price equations, we tested for the cointegration of the price and unit labor cost variables. Cointegration was not rejected for either country by any of the first three tests listed by Engle and Granger (1987, pp. 264-8; these include the Dickey-Fuller and augmented Dickey-Fuller tests), and accordingly all equations include an error-correction term. Our formulation in (26) calls for this to be entered as the difference between the log level of labor's share and its equilibrium value; in order to avoid an iterative procedure (determining the value of the equilibrium share from estimated parameters), we simply define the required

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17. This is the basic equation (2) that Coe-Krueger (1990) use to show the significance of the target-real-wage bargaining term, i.e., that  $h_j < 0$ .

18. The excess demand variables (unemployment, the output ratio, or capacity utilization) are initially entered with lags 0-3. The coefficients always change sign, indicating the presence of both level and change effects; the significance of these coefficients then determines which lag applies when the level and change are entered separately as in (26).

difference as the deviation of labor's share from its sample mean.

- **Dummy variables.** Much of the previous literature on German wages allows for a "wage push" dummy for one or more quarters in 1970. In our case the dummy variable is defined for the period 1970:Q1-1971:Q1. Some previous literature also allows for "strike dummy" in 1984:1, and we define a dummy variable equal to +1 in 1984:1 and -1 in 1984:2. We also allow the estimated NAIRU to change in selected equations for both countries by including separate dummy variables for 1973-90 and 1981-90 and then reestimating to exclude insignificant dummies. As in previous papers for the U. S., the effect of the Nixon-era price controls is assessed with dummy variables.<sup>19</sup>

- **Within-sample stability.** The use of dummy shift variables for 1973-90 and 1981-90 implicitly allows the constant term in the equation to shift while forcing all other coefficients to remain constant. To tests for shifts in all coefficients, we run Chow tests on the stability of the specification in the 1962-72 and 1973-90 subperiods. The break in 1973:1 is chosen so that the two subperiods can be interpreted as applying to the fixed and flexible exchange rate regimes. As we shall report below, the German wage and U. S. price equations fail the test for stability, and accordingly we base our conclusions on the versions estimated for the 1973-90 subperiod. The U. S. wage and German price equations pass the test for stability, indicating the the parameters

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19. As in Gordon (1990, notes to Table 3) and previous papers by Gordon cited there, the Nixon controls "on" dummy variable is entered as 0.8 for the five quarters 1971:1-1972:3. The "off" variable is equal to 0.4 in 1974:2 and 1975:1 and to 1.6 in 1974:3 and 1974:4.



estimated for the full 1962-90 period remain stable.

### *Estimated Wage Equations*

The estimated wage equations for Germany are summarized in Table 4; here we discuss the main features of the coefficients and defer to Table 8 a discussion of the estimated NAIRUs and adjustment parameters. Significance values for coefficients or sums of coefficients are indicated by (\*) or (\*\*), as indicated in the notes to the table. Lag lengths are listed on the left of the table; when more than one lag is included on a particular line, the listed numbers and significance levels refer to the sum of coefficients. For the full sample period 1962-90 column (2) differs from column (1) only by excluding insignificant variables or lags.<sup>20</sup> Because a Chow rejects stability over a break of the 1962-90 sample period in 1973, we focus primarily on the results for 1973-90 shown in columns (3)-(5).<sup>21</sup> The unusual nature of the 1962-72 period is evident in Figure 2, which plots the labor cost, price, and income share variables for Germany. Highly volatile wage behavior in the 1967-68 recession and in the 1970-71 "wage explosion" period was not repeated after 1972. Figure 3 shows the same variables on the same scale for the U. S. and displays much more persistent and less volatile wage behavior.

The 1973-90 German wage equation in column (3) corresponds exactly to the 1962-90 equation in column (2), except for the exclusion of inapplicable dummy shift variables. Column (4) shifts from four lagged values of the unemployment to single terms in the level

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20. The tax wedge is included for 1962-90 because it is highly significant for 1973-90 in columns (3)-(5).

21. The  $F(17,77)$  ratio for a structural break in the equation in column (1) is 3.20, as compared with the 1 percent significance level of 2.13.

and change of unemployment. Finally, column (5) splits the level of unemployment between short-term and long-term unemployment. The significance of the change in labor's share on line 2 indicates feedback from prices to wages; in column (5) labor cost depends only on lagged prices, not at all on lagged wages. Both the level and change in unemployment are highly significant, indicating partial hysteresis, while the insignificance of long-term unemployment supports the insider-outsider hypothesis (the estimated  $\psi$  parameter is 0.1, as compared to the value of  $\psi = 1.0$  required for full outsider effectiveness). The error-correction term is significant with the correct sign in all equations, supporting Coe-Krueger and their interpretation of the real-wage bargaining hypothesis. The price and tax wedge terms enter with the correct signs, and the latter is highly significant in the 1973-90 period. The dummy shift term for 1981-90 is insignificant and is omitted.

Table 5 presents several alternative wage equations for the U. S. Unlike Germany, the list of supply shock terms includes two additional variables relevant in principle for price behavior, that is, changes in the relative price of food and energy, and in the relative price of imports. Starting from the basic equation in column (1), column (2) drops insignificant variables and lag lengths, column (3) shifts to a single level and change of the unemployment rate, and column (4) shows for comparison the results for 1973-90 (although stability in the 1962-90 period is supported).<sup>22</sup> Comparing column (3) with the German results in Table 4, column (4), there is similar feedback from prices to wages (although a higher U. S. sum of

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22. Because of the long lag lengths in the U. S. equation, there are insufficient degrees of freedom to run equations for the 1962-72 subperiod. Since data are available for the entire postwar period, we test structural breaks here and in Table 7 by running the same equations over the 1954-90, 1954-72, and 1973-90 subperiods. The  $F(46,52)$  ratio for the equation in Table 5, column (1) is 0.89, compared to a 5 percent significance level of 1.62.

coefficients on lagged wages), and strikingly similar effects of the level and change of unemployment. The persistence of the U. S. wage process evident in Figure 3 is captured by the long 12-quarter lag distribution, while the two humps in 1974-75 and 1980-82 are captured by the significant food-energy and import relative price terms. The main differences in the U. S. equations compared to Germany are the significance of the productivity deviation, the insignificance of the tax wedge, and the significance of the supply shift relative price terms. As we shall see in Table 8, the implied NAIRU and Phillips curve slopes are surprisingly similar in the two countries.

### *Estimated Price Equations*

The German price equations are displayed in Table 6. Two basic equations are presented, in column (1) with detrended output as the demand variable and in column (2) with the capacity utilization rate. The latter provides a slightly better fit but has the advantage of structural stability across the 1962-90 period.<sup>23</sup> The most important result in all the German price equations is the insignificance of the lagged labor share variable, implying an absence of feedback from wages to prices. This means that the NAIRU relevant to monetary policy refers to the capacity utilization rate and can be computed directly from the price equation without reference to the wage equation.

Other results evident in Table 6 are the role of partial hysteresis, the insignificance of the error-correction term when demand is measured by capacity utilization, and the significant

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23. The absence of a structural break in 1973 is barely rejected for the utilization version; the  $F(27,57)$  ratio is 1.32 compared with the 5 percent critical value of 1.65. With the log output ratio the  $F(27,57)$  ratio is 2.27.

and correctly signed productivity deviation and imported materials relative price terms.<sup>24</sup> An adverse shift in the capacity utilization NAIRU for 1973-90 is implied by the pattern of shift dummies on lines 11 and 12.

The American price results in Table 7 present several variants for the 1973-90 subperiod, since structural stability over the 1962-90 period is rejected.<sup>25</sup> The results indicate substantial feedback from wages to prices in both the change term on line 2 and the error-correction term on line 9. The demand effects of capacity utilization, and the support for partial hysteresis, parallel the German price results, as does the significant and correctly signed productivity deviation variable. The change in the relative price of food and energy and the change in the real effective exchange rate enter as significant and correctly signed supply shift terms. The constant and 1973-90 shift terms are insignificant in columns (5) and (6), and the equations are reestimated with these terms omitted.

### *Estimated Parameters: Adjustment, Hysteresis, and NAIRU*

The estimated coefficients in Tables 4-7 can be unscrambled to reveal the main parameters of interest, using the relationships displayed in equation (19) above. These determine the coefficient of response ( $g_i$ ) of wages or prices to a deviation of actual unemployment from the contemporaneous no-shock natural rate of unemployment ( $U_i^{NS}$ ), the

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24. A coefficient of -0.10 on the deviation of productivity from trend means that 10 percent of a cyclical increase in productivity takes the form of lower prices and the remaining 90 percent takes the form of higher profits.

25. As in Table 5, the Chow test is conducted for a break in 1973 over the period 1954-90. The  $F(25,84)$  ratio for the output ratio version in Table 7, column (1), is 1.88 and for the utilization version in column (2) is 2.65, both higher than the 5 percent critical value of 1.65.

hysteresis coefficient ( $\phi$ ), and the steady-state no-shock NAIRU ( $U_i^*$ ). Analogous parameters are presented for the price equations, where capacity utilization is the preferred demand variable.

The first section of Table 8 shows that the estimated response coefficient ( $g_j$ ) is quite similar for the two countries in both the wage and price equations. The absolute size of the response coefficient is lower for the price equation, simply because the demand variable in these equations (the capacity utilization rate) is more volatile than the unemployment variable entered into the wage equations. The estimated hysteresis coefficients in the next section of Table 8 indicate surprisingly similar behavior in both Germany and the U. S. , and in both the wage and price equations.

NAIRU estimates require reestimation of each equation with this sum of coefficient restricted to sum to unity, as assumed in the algebra of equations (12) through (19) above, and the results are shown in the third section of Table 8. Perhaps the most surprising result of this paper is that the NAIRU implied by the German and American wage equations is identical over the entire 1973-90 period at about 6.2 percent. The natural rate of capacity utilization for the U. S. is simply the mean value of 81.7 percent, since the constant term is insignificant and excluded from the relevant equation. The natural rate of capacity utilization for Germany is close to its mean value of 84.4 percent in the restricted equation estimated for the 1973-90 sample period.

While the estimated NAIRU from the German wage equation provides the optimistic interpretation that German unemployment had not fallen below the NAIRU by the end of

the sample period in 1990:4, this optimism is tempered by the pessimistic conclusion of the price equation. Utilization was more than 5 points above the natural rate, according to the price equation, and this is what counts in view of the absence of feedback from wages to prices.

### *Dynamic Simulations*

To test the stability of these wage and price equations, we subjected them to dynamic simulations for the 10 years beginning in 1981:Q1. The upper part of Table 9 displays simulations that feed back the equation's own prediction of the lagged dependent variable (prices or labor cost), while holding the change and level of lagged labor's share exogenous. The lower part is a more demanding test, calculating both wages and prices together. In such simulations it is possible for the computed inflation rate to drift substantially away from the actual 1981-90 values. The most important statistic is the mean error of the simulation; a large positive or negative value of this statistic indicates that the simulated values drift substantially away from the actual values. Shown also are the root-mean-squared errors.

The results are encouraging, particularly the extremely low mean errors for the wage equations in both countries. There is moderate drift in the German price equation, with an average underprediction of actual 1981-90 inflation by almost half a percentage point at an annual rate. The U. S. equations stay on track remarkably well in the dynamic simulations in the bottom part of the table.

### *Implied NAIRU from Dynamic Simulations*

What are the implications of these equations for the NAIRU? We would like to use the estimated coefficients in the wage and price equations to simulate the effects of different paths of the unemployment rate over the period 1991-2000, both to check the value of the NAIRU and to measure how rapidly inflation accelerates when unemployment is reduced below the NAIRU. However, since the wage equations use unemployment and the price equations use the capacity utilization rate, a full dynamic simulation of the inflation rate implied by alternative unemployment rates would have to add a separate "Okun's law" equation linking capacity utilization to unemployment.

To avoid adding complexity to the model, as an expedient we reestimate the price equation for each country (using the particular variant listed in Tables 8 and 9), replacing the capacity utilization rate by the unemployment rate. The top part of Table 10 shows the inflation rate for selected periods for two alternative paths of the unemployment rate, a path "A" which holds the rate constant at 6 percent and another path "B" that reduces it to 5 percent by the end of 1991 and holds it there through the year 2000. The contrast between the German and U. S. results is remarkable. While inflation is stable in both countries at a 6 percent unemployment rate, the path B demand expansion causes a slow but steady acceleration in the U. S. that is absent in Germany. This contrast might cause us to leap to the conclusion that German policymakers can expand the economy as much as they want without adverse inflationary consequences.

However, an alternative procedure tempers this optimism. Since we determined that

there is no feedback from wages to prices in Germany, we can simulate the price equation by itself, using utilization as the demand variable and ignoring the wage equation and the unemployment rate. Now the expansionary path B holds the utilization rate at 89 percent (a bit below the 90.4 percent rate achieved in 1990:4), while the "natural rate" path A reduces the rate to 85 percent by the end of 1991 and holds it there through the year 2000. The four point difference between paths A and B (compared to a one-point difference in the top part of the table) reflects the fact that utilization is about four times as volatile as unemployment over the typical business cycle in Germany.

The results are shown in the bottom section of Table 10; the predicted inflation along path A is roughly the same as in the top part of the table, but inflation accelerates significantly along path B. The acceleration (measured by the difference between inflation along paths B and A) starts faster than the U. S. result in the upper part of the table, but cumulates less by the year 2000. This difference reflects the persistence of the U. S. inflation process, with its long lags and mutual feedback between wages and prices.

Why do the two procedures for Germany yield such different results? The reason is that the top part of the table replaces the utilization rate, the demand variable that "belongs" in the price equation, with the unemployment rate. The fit deteriorates, and most notably the "level effect" of unemployment almost disappears, leaving an equation that displays nearly full hysteresis and hence for which the NAIRU cannot be defined. In contrast, there is a significant "level effect" in the version that uses utilization (e.g., Table 6, column 5), and this equation should be viewed as more reliable. The utilization version is more reliable both



because it fits better, and also because the relationship between utilization and unemployment in Germany is dominated by a strong trend (implying misspecification of an inflation equation that uses unemployment as a demand variable but omits the role of this trend).

As shown in Figure 4, the German "Mean-Utilization Rate of Unemployment" (MURU), the unemployment rate consistent with the 1962-90 average mean utilization of 84.4 percent, rose from 2 percent in 1973 to 3.4 percent in 1980 to 8.0 percent in 1986, before falling to 7.3 percent in 1990.<sup>26</sup> Since the inflation equation is stable with respect to the utilization rate, this series for the MURU represents our final estimate of the German NAIRU. It implies that in the 1989-90 period, when unemployment fell to 6.2 percent and utilization rose above 90 percent, the German economy became significantly overheated. The German MURU is contrasted in Figure 4 with the MURU for the U. S., which is stationary and displays long swings in the range of 5 to 7 percent, with troughs in 1969-72 and 1987, and a peak in 1978-81.

## VI. CONCLUSIONS

This paper provides a new interpretation of wage and price dynamics. Its nonstructural

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26. The German MURU is calculated by running a set of regressions of the unemployment rate on lags 0-3 of the deviation of utilization from its 1962-90 mean and two piecewise trends. The MURU is equal to the fitted coefficients of the trends, plus the residual in the equation. Equations are estimated over four overlapping sample periods; by running separate equations we allow the cyclical response of unemployment to utilization to vary over time, and by overlapping the equations we can blend the predicted MURU from one equation smoothly into the prediction from the next equation. The equations are estimated for 1962-73, 1972-80, 1979-85, and 1984-90. The two piecewise trends in the four equations are broken respectively in 1968:4, 1975:4, 1982:4, and 1985:4. The same procedure is used for the U. S. MURU, with four equations estimated for 1955-64, 1963-71, 1970-79, and 1978-90, with breaks in 1959:2, 1974:2 and 1987:2 (no break is found necessary in the second equation for 1963-71).

analysis integrates a number of concepts that have been treated separately in much of the literature, including Phillips curve "level effects," hysteresis "change effects," the error-correction mechanism, and the role of changes in labor's share in acting as a supply shock in the inflation process. Its structural analysis is complementary, deriving a role for changes in the tax and price wedge terms as supply shift variables, and showing how the insider-outsider and real-wage bargaining models may be interpreted in the more general context of the nonstructural approach.

An important analytical conclusion that builds on prior literature is the distinction among the shock, no-shock, and contemporaneous concepts of the NAIRU. The no-shock NAIRU relevant for monetary policy can be overstated in the presence of adverse supply shocks, unless variables are included in wage and price equations to control for such shocks. More novel is the stress on feedback between the wage and price equations, achieved by an algebraic transformation that introduces changes in labor's share as the primary feedback variable, with an additional role for the log level of labor's share as the error correction term. Since the primary target of monetary policy is inflation itself, not changes in labor cost, the wage equation is irrelevant to the estimation of the NAIRU if there is no feedback from wages to prices.

In this light the paper reaches two striking conclusions. The first is that during 1973-90 German wage behavior was remarkably similar to that in the U. S., with almost identical estimates of the Phillips curve slope, of the hysteresis effect, and of the NAIRU emerging from the respective wage equations. In particular, both countries are characterized by partial but

not full hysteresis in the wage equation, and the NAIRU indicated by the wage equation is about 6 percent in both countries in 1990.

But the second conclusion indicates an important difference between the two countries. In Germany (not the U. S.) there is no feedback from wages to prices. Thus our relatively optimistic estimates of the German NAIRU emerging from the wage equation are irrelevant to the determination of inflation and to an evaluation of the monetary policy of the Bundesbank. Instead, we find that inflation has a stable relationship to the capacity utilization rate, and that the "natural rate of capacity utilization" of about 85 percent is well below the actual rate of 90 percent reached in 1990. The economy was overheated and inflation accelerated, justifying the subsequent monetary tightening by the Bundesbank. The implied NAIRU consistent with steady inflation in Germany was 7.3 percent in 1990; this is the unemployment rate consistent with mean utilization (MURU) in that year. This estimate lies in the middle of the estimated NAIRU range of 5.5 to 9.0 percent appearing in the recent German literature.

Because there is mutual feedback between wages and prices in the U. S., both the wage and price equations matter for inflation dynamics and monetary policy. Fortunately, both the wage and price equations tell a consistent and familiar story. The U. S. NAIRU is estimated from the wage equation to be roughly 6 percent, a familiar finding from previous research. The equilibrium rate of U. S. capacity utilization in the price equation is about 82 percent, almost precisely the rate which is consistent with a 6 percent unemployment rate. Because of long lags in wage and price formation, policymakers face considerable danger in allowing the

unemployment rate to fall much below 6 percent. A decade of 5 percent unemployment is estimated to cause a slow but powerful acceleration of inflation which eventually reaches double digits. The counterpart of this result is that the two years of unemployment above 6 percent in 1991-92 have achieved a permanent deceleration of U. S. inflation that will not be reversed even when the unemployment rate recovers to 6 percent, as long as it does not go below that rate.

Unlike the traditional assumption that the U. S. has a uniquely flat Phillips curve, we find that its wage and price adjustment to a change in utilization or unemployment is as great as in Germany and shows more of a tendency to cumulate. This puts a new interpretation on the divergence between U. S. and German unemployment behavior in the 1980s. American inflation fell after 1982-83, because a sharp demand contraction sent unemployment far above the NAIRU, and the economy slid down a relatively steep short-run Phillips curve, bringing inflation down fast in 1981-83. During the 1987-89 boom American unemployment barely fell below the 6 percent NAIRU, and hence the post-1986 acceleration of inflation was modest. A surprise for the U. S. is that there is no evidence of unique weakness of labor or labor unions in the 1980s. Labor's income share hardly fell at all in the U. S. in the 1980s, and in fact declined much more in Germany. The American problem of slow wage growth is a productivity problem, not a wage negotiation phenomenon.

Finally, this paper does not solve the mystery of why the German NAIRU rose from the 1960s to the 1980s, but it provides a new twist. Since inflation maintains a stable relationship with the rate of capacity utilization, the German puzzle can be repackaged as the

mystery of why the mean-utilization unemployment rate (MURU) increased so much, particularly in the interval 1980-86 (since 1986 the MURU has declined slightly from about 8 to 7.3 percent). Here the contrast with the U. S. is startling. The relationship between U. S. unemployment and capacity utilization was absolutely the same in 1990 as two decades earlier, while in Germany there evolved a remarkable mismatch between the size of the labor force and the availability of industrial capacity.<sup>27</sup> In view of America's longstanding concern over its low rate of investment, it seems ironic that Germany emerges as a country that did not invest enough to provide the capacity required by its labor force.

The inadequacy of investment in Germany required tight monetary policy which, through the role of the Deutsche mark as the anchor of the European Monetary System, spilled over to the rest of Europe. To answer the question posed at the beginning of this paper, as to whether high European unemployment was due to restrictive demand or structural impediments, we conclude that both explanations are crucial. Structural factors interacting with restrictive demand policies depressed investment and slowed the growth of industrial capacity, leaving Europe in the 1980s without enough capital fully to employ its labor force. In the end, the core explanation of high European unemployment in the decade of the 1980s is a capital-labor mismatch.

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27. The U. S. capacity utilization rate was 84.3 percent in 1972 and 83.0 percent in 1990. The respective unemployment rates in these two years were 5.5 and 5.4 percent.

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**Figure 1**  
**Official Unemployment Rates**  
**Germany and the United States, 1960-1990**

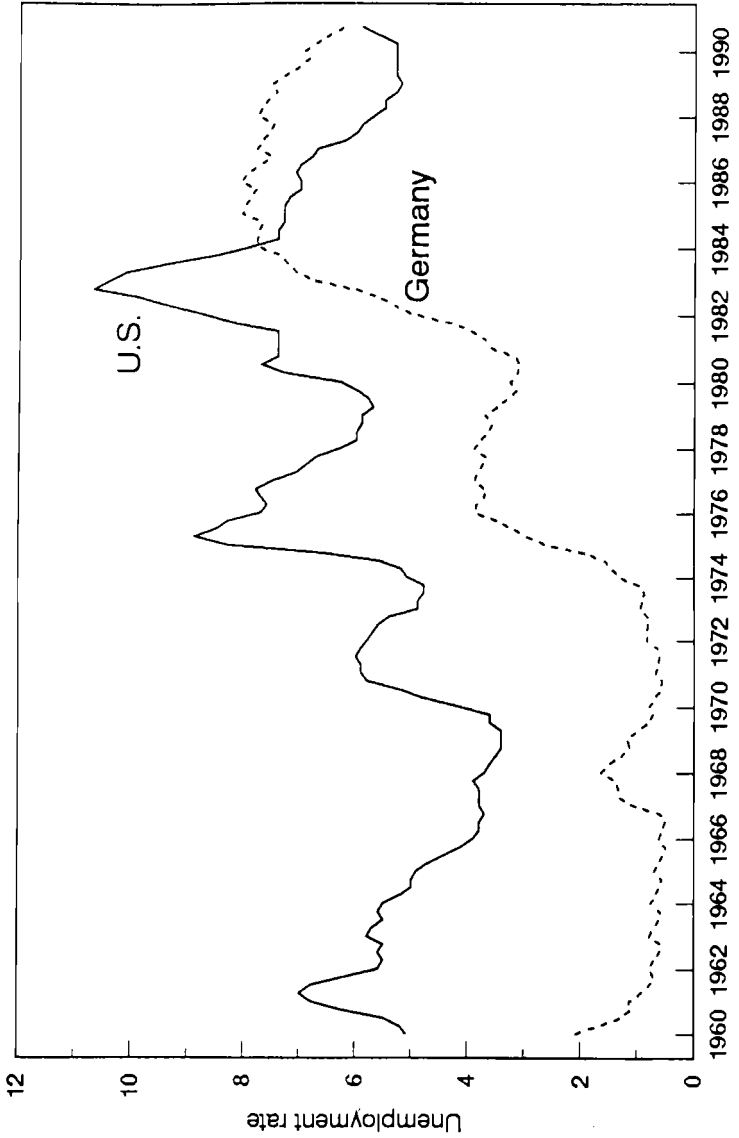


Figure 2  
Four-Quarter Changes in Price Deflator,  
Unit Labor Cost and Adjusted Labor's Share  
Germany, 1962:1-1990:4

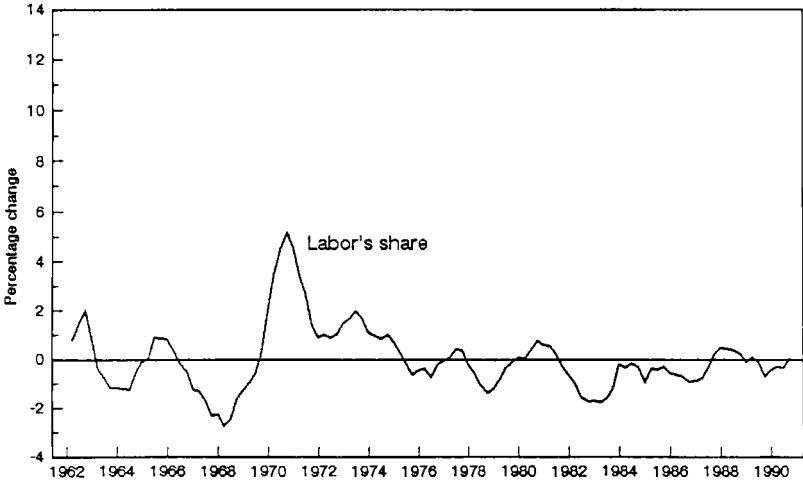
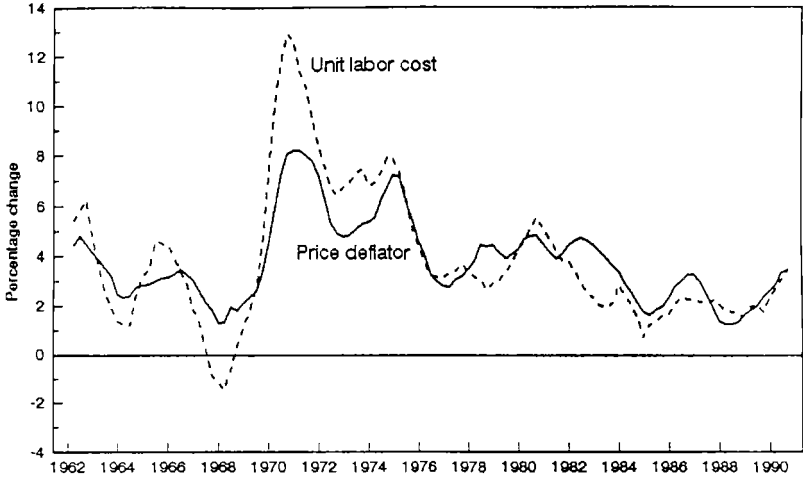
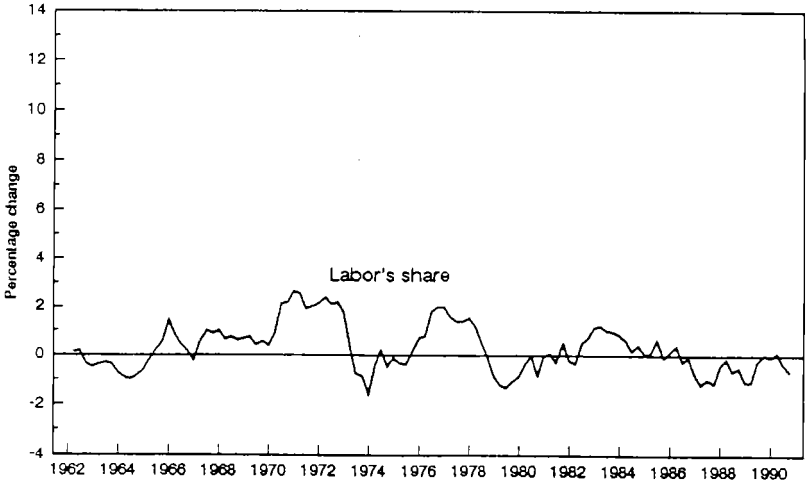
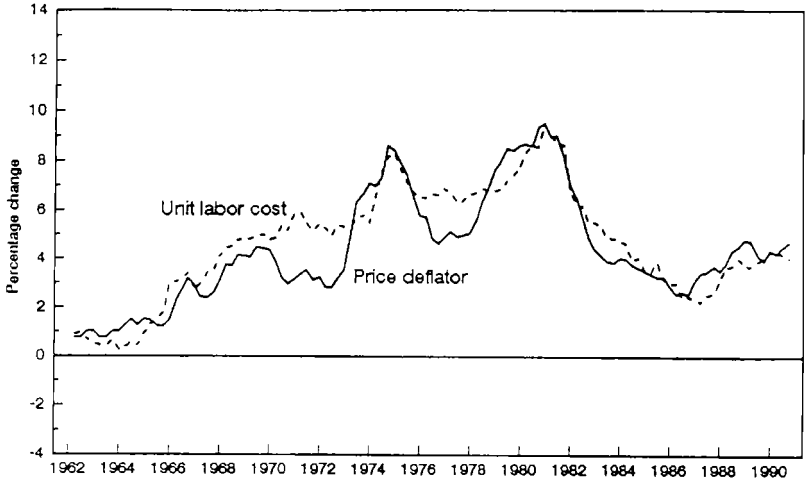


Figure 3  
Four-Quarter Changes in Price Deflator,  
Unit Labor Cost and Adjusted Labor's Share  
United States, 1962:1-1990:4



**Figure 4**  
**Mean-Utilization Rate of Unemployment!**  
**Germany and the U.S., 1962-1990**

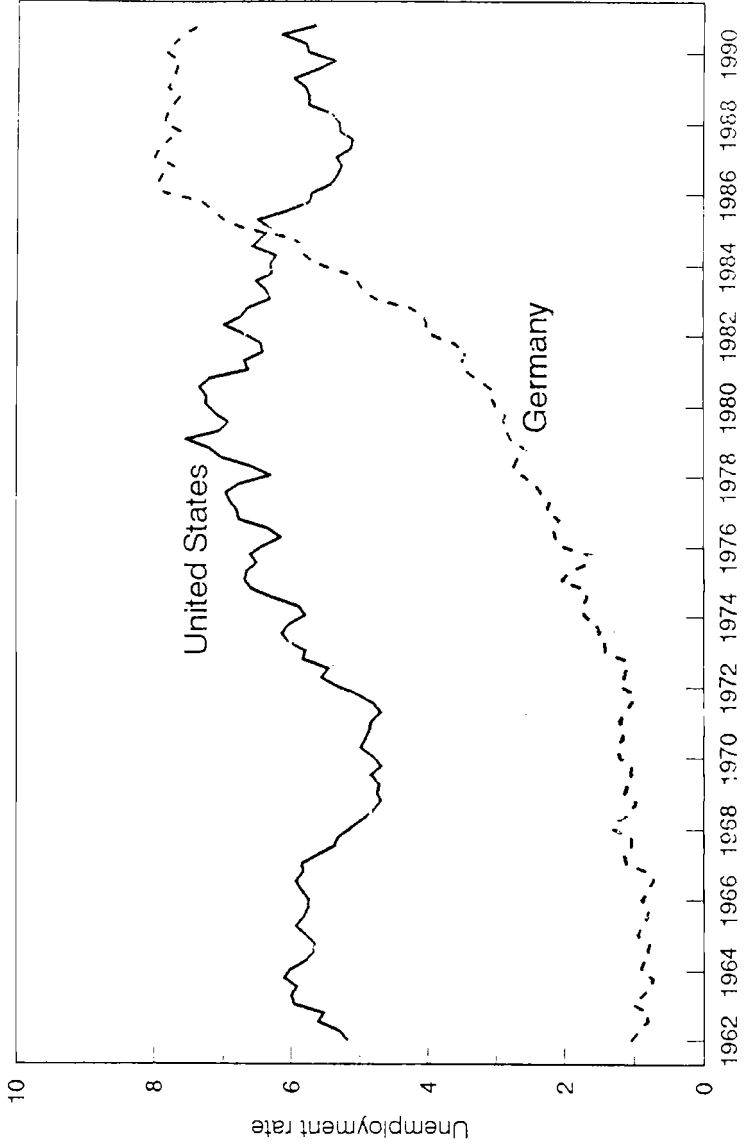


Table 1  
Summary Measures of Unemployment, Employment, and Hours

Average Over Interval	Official Unemployment Rate		Share of Long-Term Unemployed		Employed Persons (millions)		Annual Hours Per Worker	
	FRG	US	FRG	US	FRG	US	FRG	US
	1	2	3	4	5	6	7	8
1961-1964	0.6	5.8	n.a.	n.a.	20.2	62.5	2,081	1,799
1965-1969	1.0	3.8	9.1	2.1*	20.2	70.5	2,003	1,816
1970-1973	0.8	5.4	7.1	3.5	20.8	77.9	1,909	1,796
1974-1979	3.5	6.8	15.3	5.5	20.1	88.0	1,803	1,759
1980-1984	6.0	8.3	23.2	8.9	20.3	97.6	1,734	1,722
1985-1990	7.3	6.1	35.8	7.5	20.8	110.1	1,675	1,709

Note: a. Refers to 1967-69 only.

Sources: Listed after Table 3.

Table 2  
 Summary Measures of Wages, Prices, Productivity, and labor's share  
 (annual percentage growth rates)

Average Over Interval	Nominal Wage Growth		Growth Rate of GDP Deflator		Growth Rate of Real Product Wage		Actual Productivity Growth		Change in Labor's Share	
	FRG	US	FRG	US	FRG	US	FRG	US	FRG	US
	1	2	3	4	5	6	7	8	9	10
1961-1964	9.4	3.3	3.6	1.0	5.8	2.3	4.9	3.4	1.0	-1.0
1965-1969	7.3	5.3	2.7	2.9	4.6	2.4	5.2	1.8	-0.6	0.6
1970-1973	12.4	7.0	6.3	3.8	6.1	3.2	4.6	2.3	1.4	0.9
1974-1979	7.9	8.2	4.5	6.6	3.4	1.6	3.7	0.6	-0.4	1.0
1980-1984	5.0	7.3	3.9	6.3	1.1	1.0	1.6	0.9	-0.5	0.1
1985-1990	4.3	4.1	2.5	3.7	1.8	0.4	2.4	0.6	-0.6	-0.2

Sources: Listed after Table 3.

Table 3  
 Summary Measures of Labor's Share, Wedge Variables, and the Output Ratio

Average Over Interval	Labor's Share		Adjusted Labor's Share		Price Wedge (1987 = 100)		Tax Wedge		Capacity Utiliz. (Dev. from Mean)	
	FRG	US	FRG	US	FRG	US	FRG	US	FRG	US
	1	2	3	4	5	6	7	8	9	10
1961-1964	67.6	69.0	69.9	67.2	110.3	92.9	139.4	123.1	2.7	0.0
1965-1969	63.2	70.0	69.5	66.3	109.1	92.6	142.9	125.9	0.7	6.7
1970-1973	66.9	73.3	71.3	70.0	101.9	94.2	155.0	128.8	3.7	-0.3
1974-1979	69.8	73.5	71.7	72.6	102.7	97.0	167.2	131.7	-3.5	-0.8
1980-1984	71.5	74.6	71.0	75.3	104.7	98.9	173.4	134.3	0.3	-3.6
1985-1990	67.9	73.2	67.1	73.6	101.1	99.8	179.7	135.5	2.0	-0.9

**Notes to Tables 1-3, by column number in ( )**  
(numbered sources in [ ] identified at end of notes)

*Table 1. Germany* (1) Registered unemployed persons as a percentage of civilian labor force (including self-employed) [1]. (3) Percentage of unemployed more than one year. Figures prior to 1966 are not available [1]. (5) Including self-employed persons; private non-farm sector [2]. (7) Per year; aggregate economy; including self-employed persons [2].

*Table 1. U. S.* (2) Unemployed persons as a percentage of civilian labor force [7]. (4) Percentage of unemployed more than one year. Figures prior to 1967 are not available [7]. (6) Including self-employed persons; private non-farm sector [4]. (8) Per year; aggregate economy; including self-employed persons [5].

*Table 2. Germany* (1) Hourly nominal wage costs including employer's contributions to social security; private non-farm sector [2]. (3) Private non-farm sector [2]. (5) = (1)-(3). (7) Real value added per hour worked, 1985 = 100, private non-farm sector [2]. (9) = (5)-(7).

*Table 2. U. S.* (2) Employment cost index linked to average hourly earnings index times compensation of employees divided by wages and salaries. Includes employer costs for employee benefits; private non-farm sector [5] and [7]. (4) Private non-farm sector [5]. (6) = (2)-(4). (8) Output per hour, private non-farm business sector [7]. (10) = (6)-(8).

*Table 3. Germany* (1) Unadjusted labor's share as displayed in the national accounts, i.e. total wage bill divided by national income; aggregate economy [2]. (3) Cumulated index of Table 2, col. (9), set equal to Table 3, col. (1) in 1987. (5) Ratio of consumer price index to value added deflator of private non-farm sector, 1987 = 100 [2]. (7) Gross wage costs per hour divided by net take home pay per hour [2]. (9) Capacity utilization rate for industry, based on business survey data; deviation from 1960-90 mean [3].

*Table 3. U. S.* (2) and (4), same as Germany. (6) Ratio of fixed weight consumption deflator to the fixed weight deflator, 1987 = 100 [5]. (8) Gross compensation of employees divided by net take home pay. Net take home pay is defined as one minus personal tax and nontax payments divided by personal income times compensation of employees minus contributions for social insurance [4]. (10) Federal Reserve Board capacity utilization rate for industry [8].

*Sources:* [1] Official News of the Federal Labor Office, Germany. [2] German Institute of Economic Research, quarterly national accounts. [3] IFO-Institute, Munich. [4] *Economic Report of the President*, February 1992. [5] *Survey of Current Business*. [6] *Economic Indicators*. [7] Bureau of Labor Statistics. [8] *Federal Reserve Bulletin*.



TABLE 4

Estimated Equations for Quarterly Change in  
Trend Unit Labor Cost ( $w-\theta^*$ ), Germany

Variable	Lags	1962:2-1990:4		1973:1-1990:4		
		(1)	(2)	(3)	(4)	(5)
1. $\Delta$ Labor cost	1-4	1.32**	1.28**	0.83**	0.82**	0.80**
2. $\Delta$ Labor share	1-4	-0.87**	-0.82**	-0.66*	-0.57*	-0.76*
3. Unemployment	0-3	-0.25	-0.31**	-0.66**	---	---
4. Unemployment	3	---	---	---	-0.64**	---
5. ST unemployment	3	---	---	---	---	-0.93**
6. LT unemployment	3	---	---	---	---	-0.10
7. $\Delta$ Unemployment	0	---	---	---	-0.84**	-0.81**
8. Error-Correction term	1	-0.17**	-0.17**	-0.23**	-0.22**	-0.18*
9. $\Delta$ Prod. deviation	0-1	0.07	---	---	---	---
10. $\Delta$ Price wedge	1-4	0.29*	---	---	---	---
11. $\Delta$ Price wedge	2	---	0.25**	0.14	0.14*	0.17*
12. $\Delta$ Tax wedge	1-4	0.07	0.09	0.35**	0.30**	0.32**
13. Constant	---	-2.18	-2.05**	4.57**	4.54**	4.65**
14. Shift 1973-90	---	3.10	3.36**	---	---	---
15. Shift 1981-90	---	-0.12	---	---	---	---
16. Shift 1970:Q1-1971:Q1	---	4.37**	4.42**	---	---	---
17. Shift 1984:1(+1), 1984:2(-1)	---	2.57**	2.60**	2.46**	2.68**	2.62**
$\bar{R}^2$		0.85	0.85	0.86	0.86	0.86
S.E.E.		1.23	1.22	0.82	0.83	0.83
S.S.R.		131.8	140.8	36.1	37.6	37.1

Notes: (\*) indicates that coefficient or sum of coefficients is significant at 5 percent level; (\*\*) at 1 percent level.

TABLE 5

Estimated Equations for Quarterly Change in  
Trend Unit Labor Cost ( $w-\theta^*$ ), United States

Variable	Lags	1962:2-1990:4			1973:1-1990:4
		(1)	(2)	(3)	(4)
1. $\Delta$ Labor cost	1-12	1.33**	1.32**	1.32**	1.49**
2. $\Delta$ Labor share	1-12	-0.90**	-0.79**	-0.77*	-0.93*
3. Unemployment	0-3	-1.05	-0.96**	---	---
4. Unemployment	0	---	---	-0.95**	-1.17**
5. $\Delta$ Unemployment	0	---	---	-0.81**	-0.71
6. Error-Correction term	1	-0.01	-0.01	-0.01	-0.02
7. $\Delta$ Prod. Deviation	0	0.07*	0.07*	0.07*	0.10
8. $\Delta$ Price wedge	1-4	0.23	---	---	---
9. $\Delta$ Price wedge	4	---	0.21*	0.19	0.28*
10. $\Delta$ Tax wedge	1-4	0.10	---	---	---
11. $\Delta$ Food-Energy relative price	1-4	0.31	---	---	---
12. $\Delta$ Food-Energy relative price	3	---	0.30**	0.30**	0.16
13. $\Delta$ Import relative price	1-4	0.10*	---	---	---
14. $\Delta$ Import relative price	2	---	0.06**	0.06**	0.06**
15. Constant	---	5.24**	4.69**	4.63**	5.20**
16. Shift 1973-90	---	-0.09	---	---	---
17. Nixon "on"	---	0.14	0.47	0.48	---
18. Nixon "off"	---	1.15	1.23**	1.23**	1.27*
$\bar{R}^2$		0.88	0.89	0.89	0.87
S.E.E.		0.84	0.81	0.80	0.80
S.S.R.		45.9	51.4	52.1	25.1

Notes: Same as Table 4.

TABLE 6

Estimated Equations for Quarterly Change in  
Product Price Deflator (p), Germany

Variable	Lags	1962:2-1990:4				1973:1-1990:4
		(1)	(2)	(3)	(4)	(5)
1. $\Delta$ Product price	1-4	0.92**	0.98**	0.98**	0.99**	0.87**
2. $\Delta$ Labor share	1-4	0.04	0.01	0.01	-0.10	-0.12
3. Output ratio	0-3	0.05	---	---	---	---
4. Capacity utilization	0-3	---	0.09*	---	---	---
5. Capacity utilization	1	---	---	0.08**	0.09**	0.14**
6. $\Delta$ Capacity utilization	1	---	---	0.13**	0.16**	0.08*
7. Error-Correction term	1	-0.24**	-0.12	-0.12	0.01	0.16
8. $\Delta$ Product deviation	0	-0.08	-0.11*	-0.10*	-0.10*	-0.07
9. $\Delta$ Imported Materials relative price	1-4	0.02**	0.02**	0.02**	0.02**	0.01
10. Constant	---	-0.27	-0.34	-0.34	0.15	0.38
11. Shift 1973-1990	---	1.30**	0.87*	0.86*	---	---
12. Shift 1981-1990	---	-0.58*	-0.41	-0.41	---	---
13. Shift 1970:Q1-1971:Q1	---	1.42*	1.35*	1.34*	1.58**	---
$\bar{R}^2$		0.82	0.82	0.83	0.82	0.82
S.E.E.		0.80	0.79	0.78	0.79	0.68
S.S.R.		59.9	58.0	58.0	60.5	25.7

Notes: Same as Table 4.

TABLE 7

Estimated Equations for Quarterly Change in  
Product Price Deflator (p), United States

Variable	Lags	1962:2-1990:4		1973:1-1990:4			
		(1)	(2)	(3)	(4)	(5)	(6)
1. $\Delta$ Product price	1-12	0.78**	0.77**	0.88**	0.97**	0.78**	0.85**
2. $\Delta$ Labor share	1-12	0.72**	0.69**	0.61**	0.51**	0.51**	0.39*
3. Output ratio	0-3	0.08	---	0.15	---	---	---
4. Output ratio	3	---	---	---	0.17*	---	---
5. $\Delta$ Output ratio	0	---	---	---	0.15**	---	---
6. Capacity utilization	0-3	---	0.15**	---	---	0.11	---
7. Capacity utilization	3	---	---	---	---	---	0.15**
8. $\Delta$ Capacity utilization	0	---	---	---	---	---	0.13**
9. Error-Correction term	1	-0.07	-0.02	0.46**	0.39**	0.27**	0.22**
10. $\Delta$ Productivity deviation	0-1	-0.19**	-0.16**	-0.20*	-0.17*	-0.17*	-0.12*
11. $\Delta$ Tax wedge	0-1	0.17*	0.13	0.15	---	0.12	---
12. $\Delta$ Price wedge	1-4	0.53*	0.59*	-0.10	---	0.01	---
13. $\Delta$ Food-Energy relative price	0-3	0.61**	0.52*	1.28**	0.86**	0.88**	0.50*
14. $\Delta$ Imports relative price	0-3	-0.07	-0.05	0.03	0.02	0.02	0.03
15. $\Delta$ Real Exchange Rate	2-5	-0.03*	-0.03*	-0.05**	-0.03**	-0.03*	-0.02*
16. Constant	---	-0.04	2.19	-1.19	-1.31*	---	---
17. Shift 1973-1990	---	1.09	0.99	---	---	---	---
18. Nixon "on"	---	-0.94	-0.42	---	---	---	---
19. Nixon "off"	---	0.27	0.18	1.23	1.12*	0.62	0.93*
$\bar{R}^2$		0.89	0.91	0.94	0.94	0.95	0.94
S.E.E.		0.79	0.72	0.54	0.53	0.49	0.53
S.S.R.		38.9	32.1	6.1	8.3	5.4	8.4

Notes: Same as Table 4.

TABLE 8

Parameter Values Implied by Tables 4-7

Dependent Variable	Trend Unit Labor Cost ( $w-\theta$ )		Price Deflator ( $p$ )	
Activity Variable	Unemployment Rate		Utilization Rate	
Equation	Germany Table 4, Column 4	U.S. Table 5, Column 3	Germany Table 6, Column 5	U.S. Table 7, Column 6
Phillips Curve Slope ( $g_T$ )	1.48	1.76	0.22	0.28
Hysteresis Coefficient ( $\phi$ )	0.57	0.46	0.36	0.46
"Natural Rate" of unemployment or utilization (1973-90) <sup>a</sup>	6.20	6.22	84.7	81.7
Actual rate of unemployment or utilization, 1990:4	6.22 <sup>b</sup>	5.90	90.4 <sup>b</sup>	80.8

Notes: a. Natural rates are computed from versions of each equation that constrain the sum of coefficients on the lagged dependent variable to be unity.

b. Seasonally adjusted by the authors

TABLE 9

Mean Errors (ME) and Root Mean-Squared Errors (RMSE)  
from Dynamic Within-sample Simulations, 1981:1-1990:4

	Rate of Change of Price Deflator		Rate of Change of Trend Unit Labor Cost	
	ME	RMSE	ME	RMSE
<b>Only Lagged Dependent Variable Endogenous</b>				
Germany	0.46	0.75	0.06	0.80
U. S.	0.22	0.42	0.06	1.18
<b>Both Price and Labor Cost Endogenous</b>				
Germany	0.38	0.69	0.34	0.89
U. S.	0.16	0.62	0.20	1.20

Notes: The simulations are based on the same equations listed in Table 8. The coefficients on the lagged dependent variable are freely estimated rather than restricted to sum to unity.

**TABLE 10**  
**Forecast of Inflation Rate for Selected Quarters**  
**for Different Paths of Unemployment and Utilization, 1991:1-2000:4**

	1990:4	1992:4	1994:4	2000:4
<b>Both Wage and Price Endogenous, Price Equation Reestimated with Unemployment Replacing Utilization</b>				
<b>Germany</b>				
Path B	3.5	4.5	4.2	3.9
Path A	3.5	4.0	3.6	3.5
Difference, Path B - Path A	0.0	0.5	0.6	0.4
<b>U. S.</b>				
Path B	4.7	4.8	5.9	12.9
Path A	4.7	3.9	3.8	4.2
Difference, Path B - Path A	0.0	0.9	2.1	8.7
<b>Price Equation Alone with Utilization Variable</b>				
<b>Germany</b>				
Path B	3.5	4.8	5.8	7.1
Path A	3.5	3.3	3.4	3.4
Difference	0.0	1.5	2.4	3.7

*Notes:* The simulations are based on the same equations listed in Table 8, and the coefficients on the lagged dependent variable are freely estimated rather than restricted to sum to unity. In the upper part of the table the price equations are reestimated with the unemployment rate replacing the utilization rate; Path A has 6 percent unemployment throughout, Path B reduces unemployment to 5.0 percent by 1991:4. In the bottom part Path B maintains 89 percent utilization throughout, Path A arrives at 85 percent utilization by 1991:4.