The Role of Wages in the Inflation Process

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The Phillips curve was initially formulated as a relationship between the rate of *wage* change and unemployment, yet what matters for stabilization policy is the rate of inflation, not the rate of wage change. The "wage equation," the traditional centerpiece of the aggregate supply sector of large-scale econometric models, may be redundant, misleading, or irrelevant. If price changes precisely mimic wage changes, then the wage equation is redundant, since all that is needed to guide stabilization policy is a Phillips curve expressed as a relation between inflation and unemployment, with no role for wages. If on the contrary there are systematic differences between the inflation rate and the growth rate of wages adjusted for productivity change, then changes in wage growth may be misleading as an indicator of inflation behavior and wage equations by themselves may yield inaccurate estimates of the natural rate of unemployment. If these systematic differences exist, yet wage changes do not make a statistically significant contribution to the explanation of inflation behavior, then wage equations are irrelevant to the crucial research task of estimating the natural rate of unemployment, the central macroeconomic concept that indicates to policymakers the available scope for economic expansion.

The most striking result in this paper is that wage changes do not contribute statistically to the explanation of inflation, with the profound implication that the aggregate supply process in the United States is characterized by a *dichotomy*: inflation depends on past inflation, not past wage changes. Deviations in the growth of labor cost from the path of inflation cause changes in labor's income share, and changes in the profit share in the opposite direction, but do not feed back to the inflation rate. There is no support for the age-old structural interpretation, common to almost all Keynesian large-scale econometric models, of wage equations as representing labor market behavior and of price equations as reflecting the "markup" pricing decisions of business firms. The Phillips curve wage equation matters only for the distribution of income, and the markup pricing hypothesis is dead.

The quantitative evidence supporting these surprising assertions takes the form of new estimates of econometric equations for both prices and wages extending over the full 1954–87 period and several subperiods. The format of the specification differs from any of my previous work by allowing lagged wage and price changes to enter symmetrically, rather than excluding one or the other from equations for wage and price change. An interesting transformation of the inflation equation shows that the role of wages reduces to the question as to whether changes in labor's income share mainly affect inflation or the profit share of income.

As a by-product, the new evidence yields numerous additional findings. The U.S. natural unemployment rate is still 6 percent, with no decline in the 1980's in response to beneficial demographic shifts. The U.S. inflation process is stable, with no evidence of structural shifts over the 1954–87 period. But the wage process is not stable: low rates of wage change in 1981–87 cannot be accurately predicted by wage equations estimated through 1980. However, rather than representing a "new regime," wage behavior in the 1980's, and the accompanying decline in labor's income share, can be interpreted simply as reversing the even larger increase in labor's share that occurred between 1965 and 1978.

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I. Labor's Share and the Inflation Rate

A. *Specification of the Wage and Price Equations*

A general specification of an equation for the rate of price change (p_t) is

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

where lowercase letters designate first differences of logarithms, uppercase letters designate logarithms of levels, w_t is the growth rate of a wage index, X_t is an index of excess demand (normalized so that $X_t = 0$ indicates the absence of excess demand), z_t is a vector of other relevant variables, and e_t is a serially uncorrelated error term. The vector z_t includes "supply shift" or "supply shock" variables that can alter the rate of inflation at a given level of excess demand (for example, changes in the relative price of energy), and all components of z_t are expressed as first differences and normalized so that a zero value of any element of z_t indicates an absence of upward or downward pressure on the inflation rate. Equation (1) is a general form that can encompass equations in nonstructural VAR models or, with restrictions, can be made to resemble traditional "structural" price and wage equations.

The coefficients $a(L)$, $b(L)$, $c(L)$, and $d(L)$ are polynomials in the lag operator L, and $a(L)$ is normalized so that its first element equals unity.[1] With this normalization, the term $a(L)p_t$ can be rewritten as

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

and, similarly,

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

[1] Up to this point, the notation and normalization follow Olivier Blanchard (1987), except for the distinction here between demand and supply variables, and except for my assumption that the error term is serially uncorrelated.

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

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

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 written in the form of (3) has the startling implication that *there is no such thing as a separate wage equation*. Equation (3) is a price equation and a wage equation at the same time, as can be seen when (3) is renormalized as follows:

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

Thus, without further restrictions, the "price equation" (3) and the "wage equation" (4) are alternative "rotations" of the same equation.

Two main approaches are available to identify separate wage and price 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. An alternative 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 highly likely that there is a contemporaneous correlation between w_t and the error term e_t in (3) or between p_t and e_t in (4). The contemporaneous coefficient could be restricted to a particular positive fraction, for example, 0.3 as in Blanchard (1986), or to zero in one of the two equations (for example, the wage equation in my previous papers, say, 1985). In the estimated equations in this paper, the price and wage equations are placed on an equal footing by excluding the contemporaneous wage or price term from both equations, that is,

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

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

where an identical set of X_t and z_t variables is entered into each. The wage change variables (w_t) in (3) and (4) have been replaced in (5) and (6) by wage change minus the change in labor's average product $(w-\theta)_t$, that is, the change in unit labor cost.

B. *Changes in Labor's Share and the Role of the Wage Equation*

Hiding inside equation (5) is an interesting relationship between inflation and changes in labor's income share. In the notation of (5) and (6), the change in labor's share (ΔS_t) is defined as

$$(7)\quad \Delta S_t = w_t - \theta_t - p_t.$$

The effects of changes in labor's share in the inflation equation are more transparent if (5) is rewritten in the following form, adding and subtracting the contribution of lagged inflation, $a^p(\mathrm{L})p_{t-1}$. Then we have

$$(8)\quad p_t = [a^p(L) + b^p(L)]\,p_{t-1} + b^p(L)(w-\theta-p)_{t-1} + c(L)X_t + d^p(L)z_t + e_t,$$

which, from (7), implies that lagged changes in labor's share are a determinant of the rate of inflation:

$$(9)\quad p_t = [a^p(L) + b^p(L)]\,p_{t-1} + b^p(L)\Delta S_{t-1} + c(L)X_t + d^p(L)z_t + e_t.$$

An equation for the change in unit labor cost, written in parallel form to (8), is

$$(10)\quad (w-\theta)t = [a^w(L) + b^w(L)] \times (w-\theta)_{t-1} - a^w(L)(w-\theta-p)_{t-1} + c^w(L)X_t + d^w(L)z_t + e_t^w.$$

The effect of a change in labor's share depends on the sum of coefficients (Σb_i^p) in (9). If that sum is zero, then wage changes are irrelevant for inflation, meaning that the counterpart of any increase in labor's income share is a profit squeeze rather than upward pressure on the inflation rate. If that sum is a positive fraction between zero and unity, then an increase in labor's income share becomes another form of supply shock, that is, the ΔS and z terms enter symmetrically. In short, with a positive sum of b_i^p coefficients, a change in labor's share becomes a source of "cost push" that is on an equal footing with any other type of adverse supply shock, for example, an increase in the relative price of energy or any other variable that causes a positive realization of the z_t vector. However, if the sum of the b_i^p coefficients is insignificantly different from zero, this would imply a *dichotomy* between the time-series processes determining the inflation rate and labor's share. 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.

C. *Interpretations of the Natural Rate*

The main focus in this paper is on estimates of equation (8) for price change and (10) for wage change. As a by-product of our main interest in the coefficients on labor's share in the price equation (b_i^p), we can use (8) to assess alternative time-series on the natural rate of unemployment. If (8) simply contained lagged inflation and excess demand terms, we could adopt the traditional definition of the natural rate of unemployment (U_t^*) as the rate consistent with steady inflation. However, the additional terms in (8) suggest an augmented definition: the natural unemployment rate is consistent with steady inflation when the net effect of changes in labor's share and of supply shocks is zero.

Due to space limitations, my estimates of (8) and (10) employ a single proxy for the excess demand variable X_t, the previously developed time-series on the "log output ratio." This is the ratio of actual real GNP to a piecewise log linear trend defined to equal real GNP in selected quarters when the actual unemployment rate is equal to the natural unemployment rate. In turn, the natural unemployment rate series is taken from my paper (1982); it displays a gradual increase from 5.1 percent in the mid-1950's to 6.0 percent in the late 1970's, and is assumed to remain constant at 6.0 percent during 1981–87. Below, I use forecasting tests for 1981–87 based on equations estimated through 1980 to determine whether this natural rate series, and its "dual," the log output ratio, understate or overstate the degree of "slack" in the economy in the 1980s.

II. The Data and Specification

Equations (8) and (10) are estimated for the period 1954:2 through 1987:3 in the same format as my most recent published results for U.S. quarterly data (1985), except for the free entry of both lagged price and lagged labor cost changes into the price and wage equations in place of my previous practice of excluding one or the other lagged series. As in (8) and (10), where lowercase letters designate rates of change, all variables are entered as first differences in logs, except for the proxy for X_t, the log output ratio. Data on the fixed-weight GNP deflator is used for the price-change terms, and an index of average hourly earnings adjusted for overtime, employment mix, and fringe benefits is used for the wage-change terms. The productivity growth rate entered into the equations in place of the θ_t term is a piecewise linear trend between benchmark years (θ_t^*), and the vector of supply shocks (z_t) is entered as in my earlier paper (1985). Further details are provided in the notes to Table 1.

The practical importance of the fringe benefit adjustment and of changes in labor's share is dramatized in Figure 1. Two indexes of labor's share are shown, calculated simply by cumulating the difference $(w-\theta^*-p)_t$ and expressing the cumulated index on the basis 1954:1 = 100. Of the two share indexes, that appearing as the lower index in Figure 1 is based on average hourly earnings before adjustment for fringe benefits, and the upper index includes the fringe-benefit adjustment. Thus the upper index is based on exactly the same data as the regression equations.[2] The fringe benefit adjustment cumulates to 12 percentage points over the sample period. The fringe-adjusted share index, after declining by 6 percentage points between 1954 and 1965, exhibits a sharp increase of fully 14 percentage points between 1965 and 1978, followed by a 7 point decline during 1978–87 almost back to the starting point. For the full period 1965–87, these up-and-down movements in labor's share occur at an absolute annual rate of 1 percent, large enough for estimated wage-change equations to be-

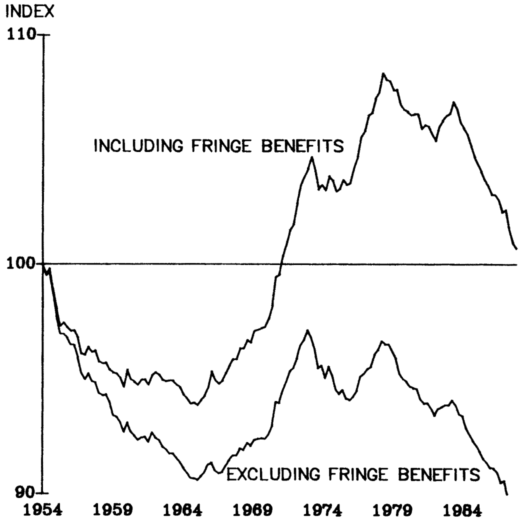

FIGURE 1. INDEXES OF LABOR'S SHARE (1954:1 = 100)

[2] These indexes do not yield precisely the same index of labor's share as could be obtained directly from the national income and product accounts, because 1) my calculation is based on trend rather than actual productivity, and 2) my wage index refers to the nonagricultural private economy while my price index refers to the total economy.

TABLE 1—BASIC EQUATIONS FOR QUARTERLY CHANGE IN FIXED WEIGHT DEFLATOR AND TREND UNIT LABOR COST, UNRESTRICTED VERSION, 1954:2–1987:3

	Fixed Weight Deflator (1)	Trend Unit Labor Cost (2)
Independent variable		
Fixed-Weight Deflator[c]	0.99[b] (8.0)	-
Trend Unit Labor Cost[c]	-	1.06[b] (4.8)
Labor Cost/Deflator[c]	0.47 (16.6)	−0.22 (4.4)
Output Ratio	0.17[b]	0.21[b]
Productivity Deviation	−0.19[a]	−0.03
Food and Energy Price Effect	0.33	0.23
Relative Import Price	0.06	0.07[a]
Relative Change in Consumer Prices	0.08	−0.02
Effective Minimum Wage	0.03	−0.00
Effective Payroll Tax	0.19	−0.18[d]
Effective Personal Tax	0.06	0.18
Effective Indirect Tax	0.51	0.21
Nixon Controls "On"	−0.84	0.17
Nixon Controls "Off"	1.19	0.21
Summary statistic		
$\bar{R}^2$	0.854	0.913
Sum of Squared Residuals	75.0	53.2
Standard Error	0.963	0.811

Notes: The dependent variable in column 1 is the quarterly change in the fixed-weight GNP deflator. The dependent variable in column 2 is the quarterly change in "trend unit labor cost," defined as the quarterly change in the fringe-adjusted BLS average hourly earnings index for the private economy minus the quarterly change in a productivity trend, defined as a piecewise linear trend of the level of nonfarm private business output per hour between the benchmark quarters of 1954:2, 1964:3, 1972:1, 1978:4, and 1986:4. The fringe adjustment consists of multiplying the BLS average hourly earnings index by the ratio in the National Income and Product Accounts of total compensation to total wages and salaries. All rate-of-change variables are expressed as annual rates, that is, as the quarterly change in the natural log times 400.

The coefficients shown on the first three lines are sums of coefficients on six sets of lagged variables. The first is the average of lags 1–4, the second is the average of lags 5–8, and so on through the sixth variable, the average value of lags 21–24.

Designating "0" as the current quarter, lag lengths for the other variables are chosen as follows: 0–4: Output ratio, food-energy effect, all tax variables; 0–1: Productivity deviation; 1–4: All others.

The Nixon controls "on" dummy variable, taken from my paper with Stephen King (1982) and my paper (1985), 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. The respective dummy variables sum to 4.0 rather than 1.0 because the dependent variable in each equation is a quarterly change expressed as an annual rate.

[a]Significance of sums of coefficients at the 5 percent level.
[b]Significance (as in a) at the 1 percent level.
[c]Number in parentheses is mean lag.
[d]See text, Sec. III.

have quite differently, and to imply a different natural rate of unemployment, than estimated price-change equations.

III. Regression Results

Table 1 presents the basic regression results for the price and wage equations corresponding to (8) and (10), where the log output ratio is used as the excess demand variable. In keeping with the view that any relevant variable could in principle influence price *or* wage behavior, I include in both the price and wage equations *all* of the supply shift variables (z_t). In the complete price equation (col. 1), the sum of coefficients on lagged inflation is almost exactly unity, indicating that the theoretical presumption of unity can be accepted. An equally important, and perhaps more surprising result, is that the sum of coefficients on the lagged labor's share variable ($w-\theta-p$) is insignificantly different from zero, with a 0.12 significance value on the sum of coefficients and a 0.24 value on an exclusion test of this variable. In parallel fashion, the labor's share variable in the labor cost equation in column 1 is also insignificant, with a 0.32 significance value on an exclusion test. These results, then, support the "dichotomy hypothesis" that wages do not matter for price behavior and vice versa.

Looking now at the other variables, the sum of coefficients on the output ratio terms is highly significant in both columns. The magnitude of these sums of coefficients is lower than in my equivalent past research, a change which stems entirely from data revisions in the national accounts. Of the supply shifts, the sums of coefficients that are significant are those for the deviation of productivity growth from trend in the price equation and the relative import price in the labor cost equation. The payroll tax in the labor cost equations is highly significant, note, however, that it enters in the form of a positive coefficient followed by a string of negative coefficients, yielding an insignificant sum. This pattern can be interpreted as suggesting that an increase in the effective payroll tax initially raises labor cost, but that subsequently the tax is "backward shifted" from employers to workers.

A. *Implications for the Natural Rate of Unemployment*

The log output ratio entered into all of the regression equations thus far in the paper is constructed as the "dual" to a hybrid natural unemployment rate series (U_t^{G*}) used in previous research. For readers of this paper, then, the natural rate series "drops from the sky," and an assessment of this series is now overdue. Two techniques are used to provide this assessment. First, equations are rerun with dummy intercept shift terms for 1963–68, 1969–74, 1975–80, and 1981–87, and the coefficients on these shift terms are examined for significant values. A significant positive value would indicate that price and/or labor cost change was faster than the equation can explain, implying an underestimate of the natural unemployment rate, while a significant negative value would imply the opposite. Since my hybrid natural rate series (U_t^{G*}) assumes a 6.0 percent natural unemployment rate after 1980, the optimistic view that the natural unemployment rate has fallen from 6.0 to perhaps 5.0 percent in recent years would be supported by a significantly negative coefficient on the intercept shift coefficient for 1981–87.

The top section in Table 2 displays the intercept shift coefficients that are intended to measure shifts in the natural rate from the assumed series. None of these coefficients are significant. In particular, the coefficient in the price equation for the 1981–87 interval is very close to zero. The relatively large (but insignificant) positive coefficient for 1969–74 in the wage equation and corresponding negative coefficient in the price equation is the counterpart of the increase in labor's share in that interval evident in Figure 1. A joint significance test on the four intercept shift coefficients indicates a very low level of significance in the price equation, and a marginal 0.11 level in the labor cost equation.

The lower section of Table 2 provides summary statistics on dynamic simulations for 1981–87 of equations estimated for 1954–80. All simulations are dynamic in the sense that lagged price and labor cost terms are generated endogenously. The three summary statistics are 1) the error in the last 4 quarters of each 27-quarter simulation, providing a measure of the simulation's "drift" in 1986–87; 2) the average error, indicating the overall bias of the simulation, and 3) the simulation's root-mean-squared-error (RMSE), measuring its overall accuracy.

TABLE 2—PERFORMANCE OF LOG OUTPUT RATIO MEASURE OF EXCESS DEMAND AS MEASURED BY CONSTANT SHIFT TERMS AND BY POST-1980 SIMULATION ERRORS

Sample Period	Complete Price Equation (1)	Complete Labor Cost Equation (2)
1954–87:		
Coefficients on Shift Dummies:		
1963:1–1968:4	−0.20	0.31
1969:1–1974:4	−0.56	0.65
1975:1–1980:4	−0.11	0.45
1981:1–1987:3	−0.06	−0.48
Joint Significance of Dummies	0.88	0.11
1954–80:		
Dynamic Simulation Errors:		
Average 4-Quarter Error for 1987:3	−0.93	−1.72
Average Error for 1981:1–87:3	−0.27	−1.76
Root Mean Square Error for 1981:1–87:3	1.15	2.09

The mean error for the price equation is extremely low, only −0.27 percent at an annual rate, indicating only a slight tendency to overpredict the inflation rate. Drift began in 1986–87, leading to a larger −0.97 percent error in the year ending in 1987:3. The RMSE is 1.15 percent, only a bit higher than the sample period standard error (for the 1954–80 interval) of 1.04 percent. Since it is the price equation that matters for the natural rate of unemployment, the low mean error for 1981–87 suggests that my assumed natural rate series remains accurate for this period. There is no evidence that the natural rate has drifted down below 6 percent; this is particularly true when the labor cost variable is excluded from the price equation, in which case too little inflation is predicted in 1986–87. The large overpredictions of inflation in the labor cost equation in Table 2 are the counterpart of the decline in labor's share in the 1980's and have no implications for the natural rate of unemployment.

IV. Conclusion

Traditionally wage equations of the Phillips curve variety are the central element explaining inflation in large-scale Keynesian econometric models. Price changes are specified as determined by a "markup" price equation and have little life of their own, mainly mimicking wage changes. Such a view of the inflation process is rejected by this paper. A relatively unrestricted equation for price change can be converted into a form in which wage changes enter only in the form of lagged changes in labor's share. When the labor's share variable is statistically insignificant, as reported here, *wage behavior becomes irrelevant for inflation*. Differences in the behavior of labor cost and inflation imply changes in labor's income share which alter the profit share of income in the opposite direction.

The paper also concludes that price changes are irrelevant for wage changes, that is, that both prices and labor costs live a life of their own. Here the evidence is less clear than in the price equations; an alternative version that allows the distribution of coefficients on lagged prices and wages to shift after 1967 indicates that either prices or wages provide an adequate explanation of wage changes. None of these equations, however, provide any substantive explanation of the sharp increase in labor's income share during 1965–78 or its subsequent decline. Thus the results are consistent with those who claim that the decade of the 1980s has witnessed a "new regime" in wage formation; virtually all of my estimated wage equations show a marked tendency to overpredict wage change for 1981–87 on the basis of coefficients estimated for 1954–80. That is, from the point of view of the equations, wage changes in 1981–87 have been too low.

No evidence is provided here on the causes of such a new regime in wage behavior in which labor's share has fallen, nor indeed on the causes of the old regime in which labor's share rose from 1965 to 1978. In fact, the new regime may just represent the unwinding of the old regime. It is notable that the timing and extent of this change in labor's share parallels that which occurred in most European countries at the same time, leading to skepticism that factors unique to the United States, for example, foreign competition, deregulation, and waning union power, have caused the turnaround in labor's share. The parallel timing of the U.S. and European rise and fall of labor's income share may also throw cold water on those who have stressed unique aspects of European wage behavior as an underlying cause of high European unemployment in the 1980's.

Given its successful past performance, it is interesting to use this paper's inflation equation to generate predictions for the future. If we make the crucial assumption that all supply-shift variables have future effects netting out to zero, we can run dynamic simulations of the price-change equation starting in 1987:4 for two different assumed paths of the unemployment rate.[3] The first path calls for unemployment to remain at 6.0 percent forever, and the second for unemployment to decline to 5.0 percent by 1988:4 and to remain there forever. The 6 percent unemployment path is consistent with steady inflation forever of 3.5 percent, almost exactly the inflation rate for the four quarters ending in 1987:3. A steady acceleration of inflation is implied by the 5 percent unemployment path, amounting to 1.1 points of extra inflation after five years and 2.4 points after ten years (i.e., the inflation rate reaches 6 percent in 1997).

Some may view this modest acceleration of inflation as a small price to pay for a reduction of unemployment by 1 percentage point, which would yield roughly $100 billion *per year* in extra GNP at today's prices, or more than $1 trillion over the 1987–97 decade. But these proponents of demand stimulus are obliged to indicate when, and how, the steady acceleration of inflation is to be stopped. Those who would prefer a path of steady inflation can translate the 6 percent unemployment forecast into a recommendation that the Fed maintain a steady 5.9 percent growth rate of nominal GNP, consisting of 3.5 percent inflation plus 2.4 percent for real GNP, the latter being the growth rate of natural real GNP between 1979 and 1987.

[3] The assumed unemployment paths are converted into assumed paths for the log output ratio by using the Okun's Law coefficients from my 1984 paper, which indicate that the long-run response of unemployment to a change in the log output ratio is 0.45.

REFERENCES

Blanchard, Olivier J., "Empirical Structural Evidence on Wages, Prices, and Employment," Working Paper 431, MIT, September, 1986.

______, "Aggregate and Individual Price Adjustment," *Brookings Papers on Economic Activity*, 1:1987, 57–109.

Gordon, Robert J., "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment," in Martin N. Baily, ed., *Workers, Jobs, and Inflation*, Washington: The Brookings Institution, 1982, 89–151.

______, "Unemployment and the Growth of Potential Output in the 1980s," *Brookings Papers on Economic Activity*, 1984:2, 537–64.

______, "Understanding Inflation in the 1980s," *Brookings Papers on Economic Activity*, 1985:1, 263–99.

______ **and King, Stephen R.**, "The Output Cost of Disinflation in Traditional and Vector Autoregressive Models," *Brookings Papers on Economic Activity*, 1982:1, 205–42.