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U.S. INFLATION, LABOR'S SHARE, AND THE NATURAL RATE OF UNEMPLOYMENT

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ABSTRACT

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. This paper provides new estimates of Phillips curves for both prices and wages extending over the full 1954-87 period and several sub-periods.

The most striking result in the paper is that wage changes do not contribute statistically to the explanation of inflation. 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. Additional findings are that the U. S. natural unemployment is still 6 percent, with no decline in the 1980s in response to the reversal of the demographic shifts that had raised the natural rate in the 1960s and 1970s. 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. Rather than representing a "new regime," wage behavior in the 1980s is the outcome of a longer-term process. The 1980s have witnessed a substantial decline in labor's income share that partly reverses the even larger increase in labor's share that occurred between 1965 and 1978.

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I. Introduction

The "Phillips Curve" relationship between U. S. wage and price changes on the one hand, and the unemployment rate on the other hand, was a central topic of academic interest in the 1960s and early 1970s, but drifted into the background in the past decade as the "new-classical" research agenda took center stage. Now, in the late 1980s, the concerns of policymakers around the world require that academics reexamine the behavior of U. S. wage and price behavior, on which the fate of the worldwide economic recovery may hinge. The link between U. S. wage and price behavior and worldwide prosperity is direct: any sustained acceleration of U. S. inflation will lead to restrictive monetary policy and higher U. S. interest rates which, given the openness of world capital markets, will spread abroad and lead to the possibility of a worldwide recession.

Like several of the most appealing topics in economics, the intrinsic interest in U. S. inflation behavior as a research topic is enriched by paradox. One such paradox juxtaposes recent evidence that the empirical Phillips curve has remained stable against the central role played by instability of the Phillips curve in the original statement of the Lucas critique (Robert E. Lucas, 1976) and in the attack leveled by the developers of the new-classical economics against Keynesian economics (Lucas and Thomas J. Sargent, 1978). A second paradox emerges from the role of the empirical Phillips curve, in its natural-rate reincarnation, as the tool by which the natural rate of unemployment is estimated. For some time a consensus has formed around an estimate for the U. S. natural rate of unemployment of roughly 6 percent.[1] This implies the twist that some Keynesian economists who take Phillips curve evidence seriously are cast in the stick-in-the-mud role of arguing currently against further economic expansion on the ground that in late 1987 the actual U. S. unemployment rate had declined sufficiently to reached the estimated natural rate of roughly 6 percent. Switching hats, many conservatives, particularly the pro-growth supply-siders who want full steam ahead at all times, have stolen the traditional Keynesian expansionist pulpit by arguing against monetary restraint.

A third paradox is that the Phillips curve was initially formulated as a relationship between the rate of <u>wage</u> 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, on the one hand, 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 other hand, 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 may yield inaccurate estimates of the natural rate of unemployment. A further possibility is that these systematic differences exist yet wage changes do not make a statistically significant contribution to the explanation of inflation behavior, implying that wage equations are irrelevant to the central research task of estimating the natural rate, i.e., the scope for economic expansion.

This paper provides quantitative results that address each of these three paradoxes, in the form of new estimates of Phillips curves for both prices and wages extending over the full 1954-87 period and several sub-periods. The first paradox is addressed through a reexamination of the stability of the Phillips curve, a topic of equal interest to those (e.g., William Fellner, 1979) who believed that tight money in the early 1980s should have exerted a "credibility effect" that shifted the Phillips curve, and to those (e.g., George Perry, 1980) whose analysis of wage behavior is based on "norm shifts." The second paradox is addressed through new empirical estimates of the natural rate of unemployment which focus on the possible role of demographic shifts in reducing the U. S. natural rate in the 1980s. The third paradox is addressed in a re-examination of equations explaining wage changes as contrasted to those explaining price changes. Do past wage changes contribute statistically to the explanation of inflation? Is there any support for the traditional structural interpretation of wage equations as representing labor-market behavior and of price equations as reflecting the "mark-up" pricing decisions of business firms? This new look at wage equations has a practical as well as a methodological side: does the continued slow pace of U. S. wage growth (only 2.9 percent in the year ending September, 1987) augur well for the the U. S. inflation outlook?

The most striking result in the 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 U. S. 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. The age-old structure of Keynesian macroeconomic models which combines structural Phillips-type wage equations with markup-type price equations is rejected. The Phillips curve wage equation matters only for the distribution of income, and the markup pricing hypothesis is dead.

Additional findings are that the U. S. natural unemployment is still 6 percent, with no decline in the 1980s in response to the reversal of the demographic shifts that had raised the natural rate in the 1960s and 1970s. 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. Rather than representing a "new regime," wage behavior in the 1980s is the outcome of a longer-term process. The 1980s have witnessed a substantial decline in labor's income share that partly reverses the even larger increase in labor's share that occurred between 1965 and 1978. Our econometric evidence does not explain this cycle in labor's share, but it does imply that the behavior of labor's share has lived a "life of its own," without feedback to the inflation rate.

II. Issues in the Specification of Equations for Price and Wage Change

Specification of the Wage and Price Equations

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

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

where lower-case letters designate first differences of logarithms, upper-case 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, e.g., 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 (hence energy prices enter as changes in the relative price of energy, not changes in the absolute price of energy). Except for its distinction between growth rates and log levels, which is required for the estimation of the "natural rate" of the excess demand term X_t, (1) is a general form that can encompass equations in non-structural 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.[2] With this normalization, the term $a(L)p_t$ can be rewritten as:

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

(2b) $b(L)w_t = b_0w_t + b'(L)w_{t-1}$.

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

(3) $p_t = -a'(L)p_{t-1} + b_0w_t + b'(L)w_{t-1} + c(L)X_t + d(L)z_t + e_t$.

Here we see that the price equation includes not just lagged values of price and wage change but also the <u>current</u> 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:

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

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. Excluding components of X_t or z_t from one equation but not from the other would represent an example of what Christopher Sims (1980) denounced as "incredible" exclusion restrictions.

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, e.g. 0.3 as in Olivier Blanchard (1986), or to zero in one of the two equations (e.g., the wage equation in my previous papers, e.g., 1985).[3] 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, i.e.,

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

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

while an identical set of X_t and z_t variables is entered into each.[4] 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, since two very different rates of wage change would be consistent with the same inflation rate if offset by a difference in productivity growth of the same amount.

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) $\Delta S_t = w_t - \Theta_t - p_t.$

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, $a^p(L)p_{t-1}$. Then we have:

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

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

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

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

(10) $(w\text{-}\Theta)t = [a^w(L)+b^w(L)](w-\Theta)_{t-1} - a^w(L)(w-\Theta-p)_{t-1}$

$$+ c^w(L)X_t + d^w(L)z_t + e^w_t.$$

The effect of a change in labor's share depends on the sum of coefficients (Σb^p_i) in (8). 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, i.e., the ΔS and z terms enter symmetrically. In short, with a positive sum of b^p_i 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, e.g., 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^p_i 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.

Interpretations of the Natural Rate

A simplified version of equation (8) illustrates alternative definitions of the natural rate of unemployment. We include only a single coefficient on lagged inflation and restrict its sum of coefficients ($\alpha+\beta$) to equal unity; include only a single lagged labor's share term (ΔS_t) and single supply shock term (z_t); ignore the error term; and enter the excess demand term as a constant and the current unemployment rate (U_t):

$$(11) \qquad p_t - p_{t-1} = \gamma_0 - \gamma_1 U_t + \beta \Delta S_t + \delta z_t.$$

We augment the usual definition of the natural rate of unemployment (U^*_t) as the rate consistent with steady inflation ($p_t = p_{t-1}$), by specifying in addition that the coefficients of changes in labor's share and of supply shocks are set to zero ($\beta + \delta = 0$), implying:

$$(12) \qquad U^*_t = \gamma_0/\gamma_1.$$

This procedure yields a single constant estimate of the "no-shock" natural unemployment rate for the full sample period. An alternative concept, the "shock" natural rate (U^S_t), is obtained by taking the estimated β and δ coefficients rather than setting these coefficients to zero:

$$(13) \qquad U^S_t = [\gamma_0 + \beta \Delta S_t + \delta z_t]/\gamma_1.$$

The "shock" natural rate concept states that inflation can be maintained constant in the face of a positive contribution of the change in labor's share or of the z vector only if policymakers maintain the unemployment rate equal to the quantity on the right-hand side of (13). In Gramlich's language (1979), they must "extinguish" the inflationary effects of the share increase or supply shock.

Estimating the Natural Rate

The "no-shock" natural unemployment rate in (12) must be central to the conduct of stabilization policy, as it indicates whether the current state of demand is consistent with steady, accelerating, or decelerating inflation. In actual estimation (8) is used, with a constant term and both current and lagged values of the unemployment rate replacing $c(L)X_t$. To correspond to the definition in (11) and (12), the sum of coefficients on the lagged price and wage variables in (8) is restricted to sum to unity $[(\Sigma a_i + \Sigma b_i) = 1]$. The $b^p(L)\Delta S_t$ and $d^p(L)z_t$ terms are included in the estimation, so that the estimated no-shock natural rate holds constant the influence of changes in labor's share and of supply shocks in the sample period. If these terms were erroneously omitted from the equation, and their true net contribution during the sample period was positive, the estimated no-shock natural rate would have an upward bias. The estimated natural rate that emerges from this procedure is simply the coefficient on the constant term in the equation divided by the sum of the coefficients on the unemployment rate variable (Σc_i).

If a single constant term is included in the equation, then as in (12) the estimated natural rate is forced to be a constant for the entire sample period. At least two methods are available to allow for changes in the natural rate. The first is simply to enter several constant terms. A second method, used in my own previous research (Gordon, 1982) and by Jeffrey Perloff and Michael Wachter (1979), allows the natural unemployment rate to change in response to shifts in the demographic composition of the labor force. This method replaces the official unemployment rate (U_t) by an alternative "weighted" unemployment rate (U^w_t) developed by Perry (1970), which weights different demographic groups by annual earnings. Because adult males receive a larger weight than females or teenagers, U^w_t rises less between the 1950s and 1970s than U_t. The use of a single constant term yields a constant estimated natural rate U^{w*}, and the corresponding "demographically-adjusted" natural rate for the official unemployment concept is $U^{D*}_t = U^{W*} + (U_t - U^W_t)$, where the difference in parentheses (filtered to eliminate its cyclical component) rises between the 1950s and 1970s, leading to an increasing value of the natural rate concept U^{D*}_t.

III. *From Theoretical Specification to Econometric Estimation*

This section sets out the main decisions that are made in converting the general specification of (8) and (10) into the equations for price-change and wage-change that are estimated below. Further details on data sources and lag lengths are provided in the notes to Table 3.

1. Basic format. All equations express every variable (other than the excess demand variable "X") as the first difference of logs. The wage variable (W) is the index of nonfarm private average hourly earnings adjusted for fringe benefits, overtime, and interindustry employment shifts, and the basic price variable (P) is the fixed-weight GNP deflator.

2. Past price and wage changes. The lag distributions on past inflation, labor cost, and labor's share are allowed to extend over 24 quarters. These long lag distributions reflect the net effect of all factors that cause inertia in the adjustment of wages and prices, including expectation adjustment, staggered long-term wage and price contracts, and lags in communicating price changes from one industry to another through supplier-customer relationships. In previous work I have tested the significance of lags 13-24, and they enter significantly in price-change equations like (8).

3. Demand Pressure variables. In past research I have developed a natural unemployment rate series through 1980 that is equivalent to the demographically-adjusted U^{D*}_t concept described above. After 1980 the series is arbitrarily

assumed to continue at the 1980 U^{D*}_t rate of 6.0 percent, pending further research on demographic shifts in the 1980s. This hybrid patched-together series is labelled here as U^{G*}_t and has as its "dual" a series on "natural real GNP" which is a piecewise linear exponential trend set equal to actual real GNP in selected "benchmark quarters" when the actual unemployment rate is close to U^{G*}_t. Either the difference $U_t - U^{G*}_t$ or the log ratio of actual to natural real GNP can be used as a proxy for the excess demand term (X_t) in the theoretical price equation, and either should give closely similar results in light of the tight "Okun's Law" relation that connects the unemployment difference and the log output ratio.

Because most of my recent research on both U. S. and OECD inflation has used the log output ratio, the basic empirical results in this paper use this concept as a proxy for X_t in (8) and (10). The accuracy of this excess demand proxy is assessed both by entering intercept shift terms to test the maintained hypothesis that the intercept in these equations is zero, and by measuring the 1981-87 forecasting error of these equations when the sample period is terminated in 1980. Subsequently the significance of the intercept shift terms, and the 1981-87 forecasting error, is reported for alternative equations that enter directly, in place of the log output ratio, one of three unemployment concepts: (1) the difference $U_t - U^{G*}_t$, (2) the official unemployment rate (U_t) and a non-zero constant term, and (3) the Perry-weighted unemployment rate (U^W_t) and a non-zero constant term.

4. Productivity deviation. Reflecting the influence of research on markup price behavior by the late Otto Eckstein and others (see especially Eckstein-Fromm (1968)), the productivity variable relevant for price and wage setting (θ_t)

is labeled "standard productivity"; the ratio of the wage rate to standard productivity is "standard unit labor cost." A fruitful specification of the change in standard productivity, which I have used since 1971, is a weighted average of the actual growth rate of productivity (θ^A_t) and of a productivity growth trend (θ^*_t), as follows:

$$(14) \qquad \theta_t = \lambda\theta^A_t + (1-\lambda)\theta^*_t$$
$$= \theta^*_t + \lambda(\theta^A_t - \theta^*_t).$$

This specification replaces the single productivity variable in the general specification of (8) and (10) (θ_t), with a productivity growth trend (θ^*_t) and an additional variable, the "productivity deviation," that is, the deviation of actual productivity growth from the growth trend ($\theta^A_t - \theta^*_t$).

5. Relative Food and Energy Prices. Here, as in previous research, I measure the relative price of food and energy by the difference between the rates of change of the national accounts deflators for personal consumption expenditures and for personal consumption net of expenditures on food and energy. This variable assumes a value of zero when the relative prices of food and energy are both constant.

6. Relative Foreign Prices. As in Gordon (1985), this paper takes as its measure of imported inflation the change in the price of nonfood, nonfuel imports relative to the GNP deflator. In previous research this variable yielded more stable coefficients than the effective exchange rate.

7. Relative Changes in Consumer Prices. To this point the basic inflation variable (p) has been proxied by the fixed-weight GNP deflator. Yet the Consumer Price Index may also be relevant for wage and/or price behavior, for

instance if consumer prices are relevant for labor supply behavior and/or are the basis for cost-of-living escalators. As in previous research (1982, 1985) this term is measured as the difference in the growth rates of the Consumer Price Index (CPI) and the fixed-weight GNP deflator.

8. Effective Minimum Wage. The effective minimum wage (defined as the statutory nominal minimum wage divided by nominal average hourly earnings) is included here, as my previous research.

9. Tax Rates. The present paper includes the same three tax rates as my most recent study (1985) of U. S. quarterly data, the effective payroll, personal, and indirect tax rates. While the latter two tax rates have generally been insignificant in past studies, the payroll tax is an extremely important determinant of our fringe-adjusted wage index, since the timing of jumps in total compensation including fringe benefits is largely dictated by the timing of changes in the statutory payroll tax rate.

10. Nixon Controls. The impact of the price controls imposed by the Nixon administration is assessed with a pair of dummy variables, specified to show the cumulative displacement of the wage or price level by the controls and the extent of its rebound after the controls ended. The definition of the two dummy variables, listed in the notes to Table 3, is identical to that in Gordon (1982, 1985) and Gordon-King (1982).

11. Constant and dummy shift terms. Like X_t in the general specification, our log output ratio is defined to be equal to zero when the economy is operating with no excess demand or supply, i.e., at the natural rate of unemployment. Thus the basic specification suppresses the constant term. Shifts in the constant term over the sample period are tested by alternative versions of

the basic equation that include four dummy shift terms defined to be equal to unity in, respectively, 1963-68, 1969-74, 1975-80, and 1981-87, and zero otherwise.

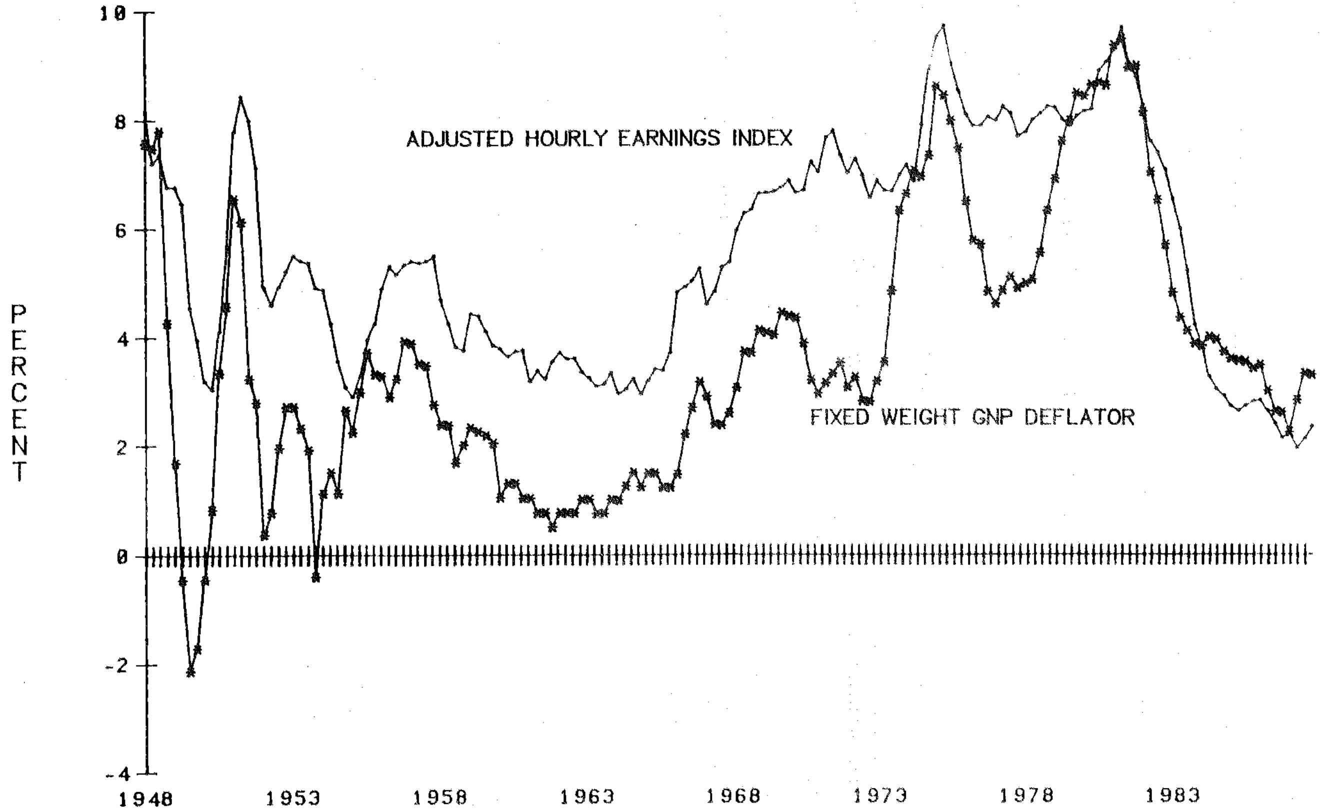
IV. Stylized Aspects of the Data

Pictures

Figure 1 displays time series plots of the basic wage change and inflation variables. Data are displayed as changes over four quarters rather than over one quarter in order to smooth erratic movements and highlight lower-frequency fluctuations (by way of contrast, all regression estimates are based on the "raw" data, that is, one-quarter changes). The time interval covered in the plots extends from 1948:1 to 1987:3. To allow for the 24-quarter lag distribution on prices and labor cost, the sample period of the regression estimates begins in 1954:2.[5]

The first feature evident in Figure 1 is the erratic nature of price and wage fluctuations from 1948 to 1953, in contrast to the relatively smooth behavior between 1954 and 1973. The close relationship between wage and price changes over the 1954-73 period is particularly notable, with the wage change index appearing to mimic the price change series plus a constant factor of about three percent. After 1973 price changes exhibit much more volatility than wage changes, and in addition the average excess of wage growth over price growth is much smaller than before 1973. Wage changes are actually lower than the inflation rate from 1983 to 1987. Part of the narrowing differerence between wage changes and inflation reflects the post-1973 slowdown in productivity growth (θ_t).

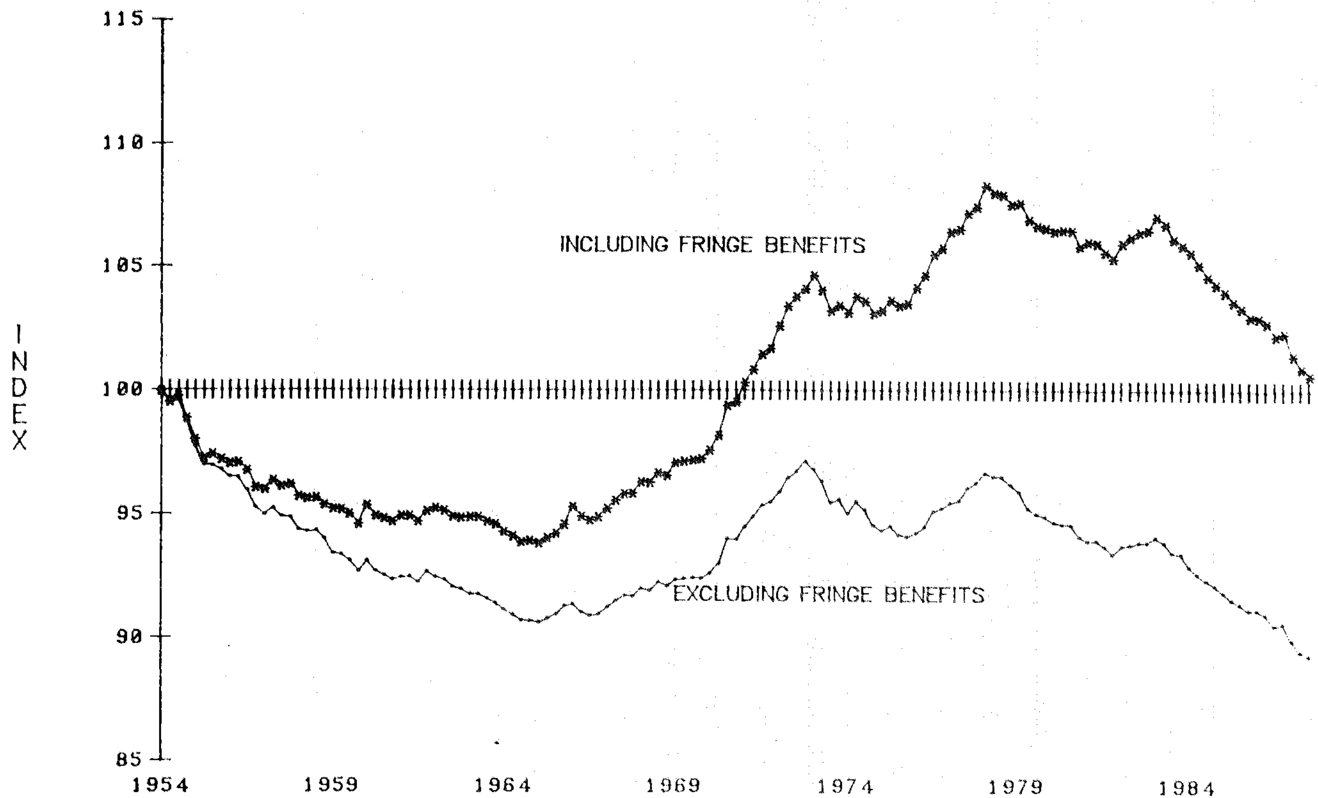
FIGURE 1
FOUR-QUARTER GROWTH RATES OF GNP DEFLATOR AND HOURLY EARNINGS



But in the 1980s wage changes have slowed even more than can be accounted for by the productivity growth slowdown, and this has been reflected in a shrinkage of labor's share, as shown in Figure 2. Two indexes of labor's share are shown, calculated simply by cumulating the difference $(w-\theta^*-p)_t$ and expressing the cumulated inde on the basis 1954:2 = 100. The trend rate of productivity growth (θ^*_t) is used in preference to the actual growth rate (θ^A_t) to eliminate the influence of cyclical fluctuations in productivity. Of the two share indexes, that appearing as the lower index in Figure 2 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 our regression equations.[6]

The practical importance of the fringe benefit adjustment and of changes in labor's share is dramatized in Figure 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 movements in labor's share occur at an annual rate of one percent, large enough for estimated wage-change equations to behave quite differently, and to imply a different natural rate of unemployment, than estimated price-change equations. The large movements in labor's share shown in Figure 2 underscore the need to determine whether mainly inflation or profits are affected. Or, as an alternative interpretation suggested above, we need to determine whether the price and wage adjustment processes are dichotomized.

FIGURE 2
INDEXES OF LABOR'S SHARE (1954:1 = 100)



Tables

Summary measures of the central variables are shown in Table 1 for intervals extending between benchmark quarters. Evident in this section is the acceleration of changes in prices, wages, and labor cost between the beginning and next-to-last period, and the ongoing deceleration of productivity growth. The negative average value of the output ratio since 1974 parallels the positive average value of the unemployment gap ($U_t-U^{G*}_t$) over the same period . Since there was negative excess demand on average after 1974, any acceleration of inflation between 1973 and 1981 must, within the framework of our model, be explained by adverse supply shifts. Also evident in Table 1 is the widening difference between the official and Perry-weighted unemployment concepts from the mid-1950s through the late 1970s, and the subsequent decline in that difference (the decline continued through 1987:3, when the difference reached 1.7 percent, down from 2.7 percent in the 1974-79 interval.)

Table 2 provides more details on the demand variables. Displayed for each benchmark quarter are the actual and natural unemployment rate, and the unemployment gap. While the log output ratio is defined to be zero in each benchmark quarter, this is not true of the unemployment gap, which generally lags behind the log output ratio by one or two quarters. In the final quarter of the sample period, 1987:3, the unemployment gap reached zero, based on the simple fact that the actual unemployment rate equaled the assumed 6.0 percent rate for the U^{G*}_t natural rate concept. However, we consider it premature to conclude that the output gap has reached zero, since the decline in the actual unemployment rate is so recent. For the period after 1979:3 natural output is assumed to grow at a geometric trend rate chosen to minimize the simulation

TABLE 1

Summary Measures of Basic Data,
Selected Intervals, 1954:2-1987:3,
All Measures in Percent

	Quarterly Rates of Change							
	Fixed-Weight Deflator	Fringe-Adjusted Wage Index	Output per Hour	Trend Unit Labor Cost	Log Output Ratio	Official Unemployment Rate	U Gap	Perry Weighted Unemployment Rate
Average over interval								
1954:2-1957:3	3.10	4.56	1.68	1.98	0.81	4.52	-0.58	3.42
1957:4-1963:3	1.26	3.59	2.85	1.01	-2.48	5.93	0.74	4.44
1963:4-1970:2	2.80	5.20	1.75	3.33	3.38	4.15	-1.44	2.50
1970:3-1974:2	4.50	7.34	1.58	5.90	0.67	5.44	-0.36	3.21
1974:3-1979:3	6.59	8.22	0.85	7.11	-2.28	6.98	1.04	4.33
1979:4-1987:3	5.05	4.92	0.94	4.32	-3.60	7.75	1.77	5.49

TABLE 2

Output, Unemployment, and Productivity, Selected Quarters, 1954-87

Indicator	Benchmark Quarters[a]						
	1954:1	1957:3	1963:3	1970:2	1974:2	1979:3	1987:3
Level in Benchmark Quarter							
Unemployment rate	5.2	4.2	5.5	4.8	5.2	5.8	6.0
Natural unemployment rate (U^{G*}_t)	5.1	5.1	5.4	5.6	5.9	5.9	6.0
Unemployment "gap"	0.1	-0.9	0.1	-0.8	-0.7	-0.1	0.0
Real GNP ($1982 bil.)	1406.8	1561.5	1892.5	2406.5	2755.2	3207.4	3831.2
Log Output Ratio (%)	0.0	0.0	0.0	0.0	0.0	0.0	-1.2
Output per hour (Index, 1977 = 100)	62.6	66.4	78.8	88.7	94.5	98.8	106.5
Growth at annual rate since last benchmark							
Real GNP	-.--	2.98	3.20	3.56	3.38	2.89	2.22
Output per hour	-.--	1.68	2.85	1.75	1.58	0.85	0.94

Sources for Tables 1 and 2: National income and product accounts, U. S. Bureau of Labor Statistics, and author's calculations.

Note: a. Benchmark quarters are those at the end of an economic expansion and prior to the quarter having an unemployment rate closest to the natural rate (U^{G*}_t). 1987:3 is not treated as a benchmark quarter for the natural output level or for the log output ratio, see text.

errors of an Okun's law equation relating the unemployment gap and output ratio over the full period from 1954:2 to 1987:3.[7]

IV. Regression Results

Table 3 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. All equations in Table 3 are estimated over the full sample period, 1954:2–1987:3. Six versions are shown, the complete price and wage equations in columns (1) and (4), respectively, and restricted versions in the other columns that omit either lagged price change or lagged wage change as indicated. In keeping with the view that any relevant variable could in principle influence price or wage behavior, we include in both the price and wage equations all of the supply shift variables (z_t).

In the complete price equation (column 1), the sum of coefficients on lagged inflation is almost exactly unity, indicating that 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–θ–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 basic labor cost equation in column (4) is also insignificant, with a 0.32 significance value on an exclusion test. The other columns in Table 3 report on alternative versions that have lagged prices or labor cost excluded. The summary statistics indicate in columns (2) and (3) that the fit of the price equation deteriorates much more if price is excluded than if labor cost is excluded. Columns (5) and (6) indicate that the

TABLE 3

Basic Equations for Quarterly Change in Fixed Weight Deflator and Trend Unit Labor Cost, Unrestricted Version, 1954:2-1987:3

Independent variable, summary statistics	Fixed Weight Deflator			Trend Unit Labor Cost		
	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable						
Fixed-weight Deflator	0.99**	-.--	1.03**	-.--	1.06**	-.--
(Mean lag)	(8.0)		(7.0)		(5.0)	
Trend unit labor cost	-.--	1.02**	-.--	1.06**	-.--	1.06**
(Mean lag)		(10.1)		(4.8)		(4.6)
Labor cost/Deflator	0.47	-.--	-.--	-0.22	-.--	-.--
(Mean lag)	(16.6)			(4.4)		
Output ratio	0.17**	0.17**	0.20**	0.21**	0.33**	0.18**
Productivity deviation	-0.19*	-0.20*	-0.11	-0.03	0.02	-0.03
Food and energy price effect	0.33	0.63**	0.53*	0.23	0.28	0.22
Relative import price	0.06	0.04	0.05	0.07*	0.12**	0.05
Relative change in consumer prices	0.08	-0.09	0.06	-0.02	0.16	-0.04
Effective minimum wage	0.03	0.03	0.04**	-0.00	0.01	0.00
Effective payroll tax	0.19	0.07	0.13	-0.18++	-0.07++	-0.22
Effective personal tax	0.06	0.03	0.02	0.18	0.20	0.12
Effective indirect tax	0.51	0.69*	-0.00	0.21	-0.22	0.30
Nixon controls "on"	-0.84	-2.31**	-0.81	0.17	1.53**	-0.43
Nixon controls "off"	1.19	1.49*	1.35*	0.21	-0.02	0.38
Summary statistic						
$\bar{R}^2$	0.854	0.840	0.851	0.913	0.895	0.912
Sum of squared residuals	75.0	88.7	82.6	53.2	69.3	57.9
Standard error	0.963	1.010	0.975	0.811	0.892	0.816

NOTES TO TABLE 3

1. Asterisks designate significance of sums of coefficients at the 5 percent (*) and 1 percent (**) levels. Plusses (++) indicate that the variable enters the equation significantly at the 1 percent level, even though the sum of coefficients is not significant at the five percent level, reflecting a pattern of significant positive coefficients followed by significant negative coefficients on lagged terms.

2. The dependent variable in columns (1) through (3) is the quarterly change in the fixed-weight GNP deflator. The dependent variable in columns (4) through (6) 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 (adjusted for overtime and the interindustry employment mix) 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.

3. 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. This technique is used to conserve degrees of freedom and to obtain a smooth lag distribution without employing the polynominal distributed lag (PDL) technique that has been used in previous papers (and which is now relatively inconvenient to implement in the RATS regression program).

4. 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.

These correspond to the lag lengths chosen in Gordon-King (1982) and Gordon (1985), with two exceptions. First, the tax variables enter with 0-4 rather than 1-4 to reflect the important hump-shaped pattern of the coefficients on the payroll tax (see comment on ++ notation above in note 1). Second, the relative import price enters with 1-4 rather than 0-3; the omission of the current term reflects the fact this variable includes the dependent variable in its definition.

5. The Nixon controls "on" dummy variable, also taken from Gordon-King (1982) and Gordon (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.

excluded than if labor cost is excluded. Columns (5) and (6) indicate that the fit of the labor cost equation declines much more if labor cost is excluded than if price is excluded. 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 all 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 food and energy effect in columns (2) and (3), the relative import price in columns (4) and (5), the minimum wage in column (3), and one or both of the Nixon controls variables in columns (2), (3), and (5). The (++) indication for the payroll tax in the labor cost equations signifies that this variable is highly significant but 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.

Tests of Restrictions, Exclusions, and Stability

A full set of tests on the exclusion of the lagged price and labor cost variables is presented in the top half of Table 4 for the full 1954-87 sample period and alternative sub-sample periods. The tests are carried out for equations in which price and labor cost change enter symmetrically (as in equations 5 and 6 above), not with the transformation in equations (8) and (10) that converts the labor cost or price variables into labor's share. The results for either of the long sample periods (ending in 1987 or 1980) supports the

TABLE 4

Significance Tests on Exclusion of Variables
(Figures shown are significance levels of exclusion tests)

Exclude tests	1954-87	1954-80	1954-70	1971-87
<u>Price Equations</u>				
Exclude labor cost	0.24	0.60	0.01	0.38
Exclude price	0.03	0.15	0.04	0.75
<u>Labor cost Equations</u>				
Exclude labor cost	0.00	0.01	0.17	0.27
Exclude price	0.32	0.88	0.56	0.28

	1954 - 87			
	No Split Lagged Variables	Split Labor Cost, Not Price	Split Price, Not Labor Cost	Split on Both Labor Cost and Price
<u>Price Equations</u>				
Exclude labor cost	0.24	0.30	0.12	0.10
Exclude price	0.03	0.20	0.02	0.05
<u>Labor cost Equations</u>				
Exclude labor cost	0.00	0.00	0.10	0.03
Exclude price	0.32	0.10	0.04	0.03

<u>Note</u>: The exclusion tests are based on alternative estimates of Table 3, columns (1) and (4), corresponding to equations (5) and (6) in the text rather than (8) and (10), so that price and labor cost enter symmetrically, not in the form of labor's share.

"dichotomy" view that price changes do not depend on lagged wage changes, while wage changes do not depend on lagged price changes. These results supporting the "dichotomy" occur equally in alternative versions that replace the output ratio with the various unemployment concepts discussed below in the text accompanying Table 6. The results are much less clear-cut for the two halves of the sample period divided in 1970-71, which is not surprising in light of the extremely small number of degrees of freedom available in these shorter sub-sample intervals.

The bottom half of Table 4 tests the same exclusion restrictions with a richer specification. Instead of restricting the lag distribution on the lagged price and/or labor cost variables to be constant over the full 1954-87 period, or we allow that lag distribution to be split into separate "early" and "late" distributions (while the coefficients on all other variables remain constant over the full sample period), an element in the specification of Gordon (1982, 1985). The split in the lag distribution occurs in 1966:4 (as in my previous papers), and the four columns in the bottom half of Table 4 show the results of the exclusion test on all price and/or labor cost variables when the split is not applied at all, is applied only to labor cost, is applied only to prices, and is applied to both. The results confirm that labor cost does not matter in the price equation for any arrangement of the split. However, the results are not so clear that lagged prices do not belong in the wage equation. When the lagged price variables are split, but the labor cost variables are not split, prices enter more significantly than labor cost, while with both variables split the significance of prices and labor cost winds up as a dead heat.

Table 5 provides two types of evidence on stability over the full 1954-87

TABLE 5

Significance Tests on Sample Splits in Unrestricted Equations
(Figures shown are significance levels of Chow tests)

Equation	1954-80 vs. 1954-87	1954-70 and 1971-87 vs. 1954-87
Complete price	0.948	0.056
Price excluding lagged price	0.917	0.080
Price excluding lagged labor cost	0.877	0.453
Complete labor cost	0.654	0.196
Labor cost excluding lagged labor cost	0.627	0.096
Labor cost excluding lagged price	0.377	0.176

Significance Tests of "Early" and "Late" Coefficients on Lagged Price and Labor Cost Variables as Contrasted with a Single Set of Coefficients on these Lagged Variables
(Figures shown are significance levels of Chow tests)

Regression	Early-late Break in 1970:4	Early-Late Break in 1966:4
Complete price	0.150	0.096
Price excluding lagged price	0.024	0.082
Price excluding lagged labor cost	0.069	0.217
Complete labor cost	0.017	0.010
Labor cost excluding lagged labor cost	0.001	0.000
Labor cost excluding lagged price	0.076	0.119

period. The top half displays significance values of Chow tests for structural breaks in 1980:4 and 1970:4. The hypothesis of a structural break is rejected at the 5 percent level in every case, although the margin is close for the complete price equation. The bottom half of Table 5 tests for the significance of the split in the lag distribution on prices and labor cost, which now is allowed to occur alternatively in 1966:4 and 1970:4. The results indicate that the split in the lag distribution is extremely significant in the complete labor cost equation and in the labor cost equation that excludes lagged labor cost. It is noteworthy that that both of these equations include lagged inflation terms, which could be interpreted at least in part as a proxy for the expected rate of inflation. I interpret this result as at least partial support for Sargent's (1971) argument that the elasticity of expected inflation to changes in actual inflation is sensitive to the policy regime (or, more precisely, the time-series properties of the series being forecast during the interval being examined). The result could also be interpreted as indicating that the fit of the labor cost equations is improved when the coefficients of the lagged inflation variables are allowed to twist after 1970 to help explain the increase in labor's share evident in Figure 2.[8] The split does not appear to be important in the price equations, supporting the view that the split helps to explain changes in labor's share but is not an important element in understanding the overall inflation process.

V. Estimating the Natural Rate of Unemployment

The log output ratio series 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^{G2}_t) 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 our hybrid natural rate series (U^{6*}_t) 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.

Coefficients on Intercept Shift Terms

The rows of Table 6 are divided into four sections corresponding to the equations displayed in Table 3, and are arranged in the same order but omit the price and labor-cost equations that exclude the lagged dependent variable. Four lines of results are displayed for each of the four equations. The first, for the log output ratio entered without an intercept, corresponds exactly to the regression results displayed thus far in the paper. Three additional sets of results are obtained by replacing the log output ratio with three alternative unemployment variables, each entered with exactly the same lag length. The second line in each section is based on the difference between the actual unemployment rate and the hybrid natural rate concept (U_t - U^{6*}_t), labelled the "unemployment gap" in Table 6, and also entered without an intercept. Since the log output ratio and unemployment gap are based on the same natural

TABLE 6

Performance of Alternative Excess Demand Variables as Measured by Constant Shift Terms and by Post-1980 Simulation Errors

	Sample Period 1954:2-87:3						Smpl Period 1954:2-80:4		
		Coefficients on Shift Dummies					Dynamic Sim. Errors		
	Unrest. S.E.E.	1963:1 -1968:4	1969:1 -1974:4	1975:1 -1980:4	1981:1 -1987:3	Joint Signif D1-D4	Error 4 Qtrs. to 87:3	Avg Error 1981:1 -1987:3	RMSE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Complete Price									
Output Ratio	0.963	-0.20	-0.56	-0.11	-0.06	0.88	-0.93	-0.27	1.15
Unempl. Gap	0.943	-0.08	-0.89	-0.09	0.37	0.53	-0.50	0.58	1.13
Actual Un.	0.952	-0.41	-1.64*	-0.52	0.84	0.15	0.60	1.41	1.65
Perry-wtd. U.	0.950	-0.76	-2.15*	-1.30	0.41	0.09	0.11	1.27	1.63
Price excl. lag labor cost									
Output Ratio	0.975	-0.22	-0.22	-0.30	0.24	0.88	1.63	0.45	1.21
Unempl. Gap	0.945	0.00	-0.22	0.20	0.54	0.74	1.69	1.41	1.63
Actual Unempl.	0.956	0.18	0.05	0.60	1.03	0.39	3.25	2.45	2.63
Perry-wtd. U.	0.940	-0.22	-0.53	-0.16	0.71	0.49	1.65	1.80	2.00
Complete labor cost									
Output Ratio	0.811	0.31	0.65	0.45	-0.48	0.11	-1.72	-1.76	2.09
Unempl. Gap	0.746	0.22	0.17	0.33	-0.25	0.54	-0.93	-0.88	1.35
Actual Unempl.	0.752	0.33	0.26	0.32	-0.04	0.90	0.37	-0.04	0.88
Perry-wtd. U.	0.748	0.01	-0.30	0.09	-0.04	0.94	0.12	-0.11	0.98
Labor Cost excl. lag price									
Output Ratio	0.816	0.33	0.62	0.65*	-0.40	0.04	-1.29	-2.35	2.67
Unempl. Gap	0.763	0.23	0.36	0.59*	-0.20	0.17	-1.41	-2.03	2.36
Actual Unempl.	0.769	0.36	0.56	0.70	0.02	0.60	-0.08	-0.81	1.24
Perry-wtd. U.	0.760	0.12	0.09	0.47	-0.03	0.85	-0.37	-0.64	1.10

Note: For meaning of asterisks, * and **, see note 1 to Table 3.

unemployment rate series, they should yield similar results. The third line in each section is based on replacing the unemployment gap with the official unemployment rate and an intercept term; this version forces the natural unemployment rate (U^*_t) to be constant. The fourth is the Perry-weighted unemployment rate, which yields the demographically-adjusted natural rate series (U^{D*}_t) described above.

The first column in Table 6 compares the standard errors of estimate for the alternative equations. The fit of the output ratio version is always inferior to any of the three unemployment variables, and generally more so in the labor cost equations than in the labor-cost wage equations. The similar pattern of the intercept shift coefficients in columns (2) through (5) for the output ratio and unemployment gap suggests than the inferior fit of the output ratio equations reflects short-term movements rather than long-run properties.

Our discussion of the intercept shift coefficients begins with the top half of Table 6 that refers to equations for price change. Two generalizations can be made about these coefficients. First, none of the coefficients on the output ratio or unemployment gap is significant, whereas one shift coefficient for the other two unemployment concepts is significant. In particular, in the first two lines of the first set, for the "complete" price equation, the downward shift in 1969-74 is insignificant, while it is significant at the 5 percent level for the other unemployment concepts. Second, the absolute value of the coefficients in the first two lines of each set, for the output ratio and unemployment gap, tends to be smaller than in the last two lines. This supports the view that either the output ratio or its dual, the unemployment gap, provides a more stable indicator of the effect of excess demand on price changes over 1954-87 than the other two concepts, the official or Perry-weighted unemployment rate.

The intercept shift coefficients for the labor cost equations in the bottom half of Table 6 are quite different than in the price equations, reflecting the marked shifts in labor's income share evident in Figure 2. The pattern of signs on these coefficients tends to be the opposite to the corresponding coefficients in the price equations, indicating that these coefficients are attempting to explain movements in labor's share that are not captured by the contribution of the demand and supply variables in the equations.

Column (6) lists the joint significance level of the four intercept shift terms. The significance level falls below 5 percent only in the first line in the fourth section, for the output-ratio version of the labor cost equation that excludes lagged inflation.

Dynamic Simulation Errors, 1981-87

The remaining columns of Table 6 provide 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 four quarters of each 27-quarter simulation, providing a measure of the simulation's "drift" in 1986-87; (2) the mean error (ME), indicating the overall bias of the simulation, and (3) the simulation's root-mean-squared-error (RMSE), measuring its overall accuracy. It is useful to distinguish between (1) and (2), since a simulation could predict too much inflation in 1981-84 but too little inflation in 1985-87, yielding a very low error in column (2) but a large error in column (1).

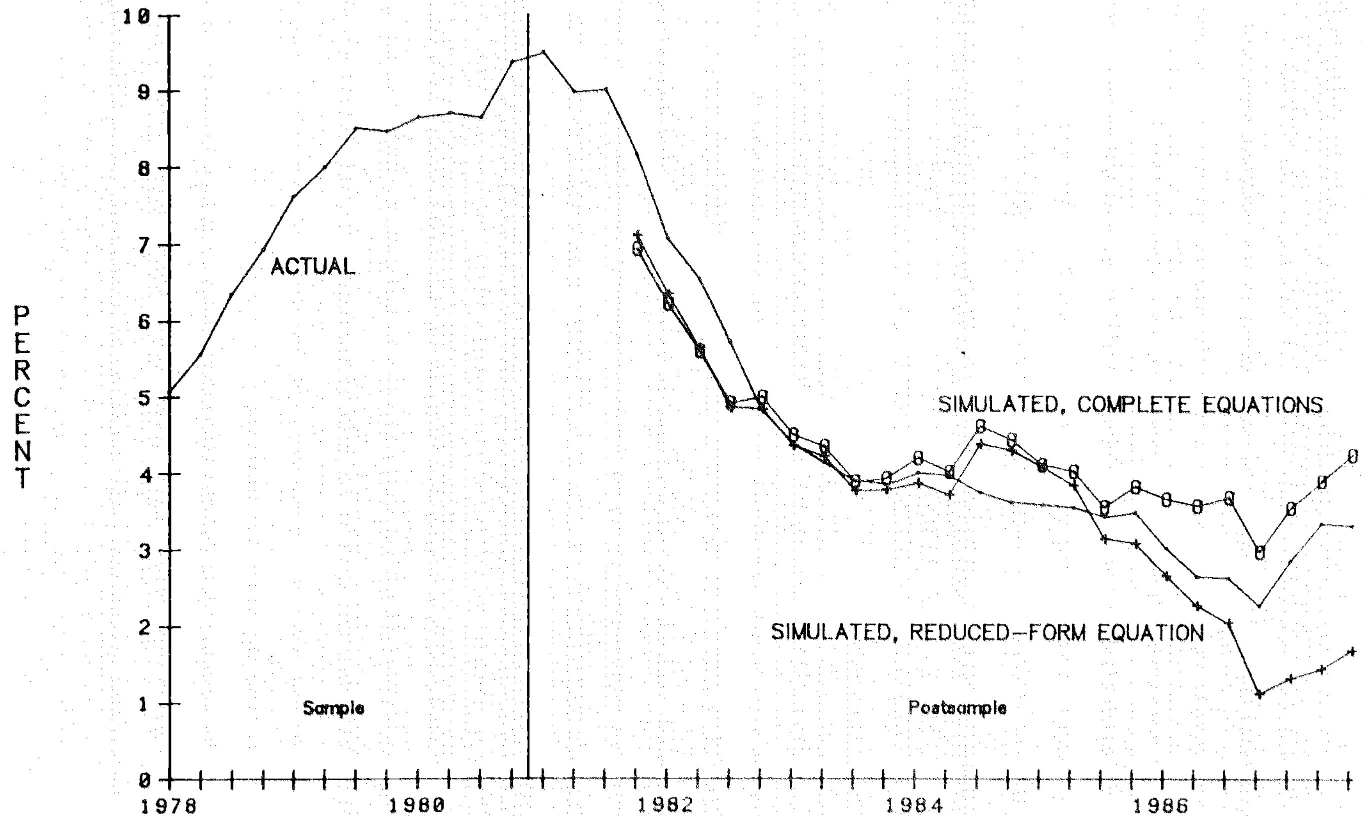
Examining the results for the price equations in the top half of Table 6, columns (7)-(9), three conclusions emerge. First, the first two lines for the output ratio and unemployment gap have uniformly lower RMSE's than the second two lines for the official and Perry-weighted unemployment rates. The ME data in column (8) indicate that the latter two concepts yield positive errors (actual inflation greater than predicted), indicating that their implied natural unemployment rate estimates for the 1981-87 period are too low, i.e., measure too much output slack.

As might be expected in light of the post-1978 decline in labor's share plotted in Figure 2, the equations for labor-cost change generate a different pattern of errors than the equations for price change. Recall, however, that the price equations are not on an equal footing with the labor cost equations, since only the former are relevant for estimates of the natural rate of unemployment. Corresponding to the post-1978 decline in labor's share is a consistent tendency for the labor-cost equations to overpredict labor cost changes. In contrast, all versions of the price equation excluding lagged labor cost <u>under</u>predict inflation after 1980.

Further insight into these simulation results is provided in Figure 3, which displays a four-quarter moving average of the actual path of inflation for 1981-87 and compares it with a four-quarter moving average of the inflation rates generated in two dynamic simulations. The first, labelled "complete equations," generates both lagged price and labor cost terms endogenously using the 1954-80 coefficients. The second, labelled "reduced form," omits the labor cost terms and thus generates endogenously only the lagged inflation terms. Through 1985:2 the two alternative simulated paths are extremely close but then diverge. From mid-1985 to mid-1987 the complete equation overpredicts and the reduced-form underpredicts. Intuitively, this occurs because the wage equation (which

FIGURE 3

ACTUAL AND SIMULATED FOUR-QUARTER INFLATION, 1978-87



generates the endogenous lagged wage terms in the complete equation) overpredicts wage changes by a substantial amount, and these overpredictions, which are omitted from the reduced form, more than overset the underpredictions of the reduced-form itself. In view of the substantial movements in energy and import prices in 1986-87, which may well have had different effects on aggregate inflation than before 1981, it is perhaps not too surprising that the admirable 1981-85 forecasting record of the price equations deteriorates as shown in Figure 3.

Policy Implications

Recall that the log output ratio and the unemployment gap series are based on the same hybrid concept of the natural rate of unemployment and thus have the same policy implications. This leaves three natural rate series to be compared, each of which is displayed in Table 7 for the same sub-sample intervals as are used to define the intercept-shift variables, and in addition for the last quarter of the sample period, 1987:3. Before the mid-1980s the hybrid and weighted concepts are quite similar, rising from the mid-1950s to the mid-1970s, in contrast to the the official concept which remains constant. But the hybrid and weighted concepts diverge in the mid-1980s, since the former remains (by assumption) at 6.0 percent, while the former falls by 1987:3 to 5.4 percent. Thus for policy decisions to be made in the late 1980s, the hybrid measure indicates less slack in the economy, and less room for stimulative demand policies, than the other two measures.

The summary data for the alternative price equations presented in the top half of Table 6 provides some guidance for choosing among these three natural rate concepts (recall that wage equations by themselves are not relevant for

TABLE 7

Alternative Estimates of
the Natural Rate of Unemployment,
Complete Price Equation with no Shift Dummies,
Six Intervals, 1954-87

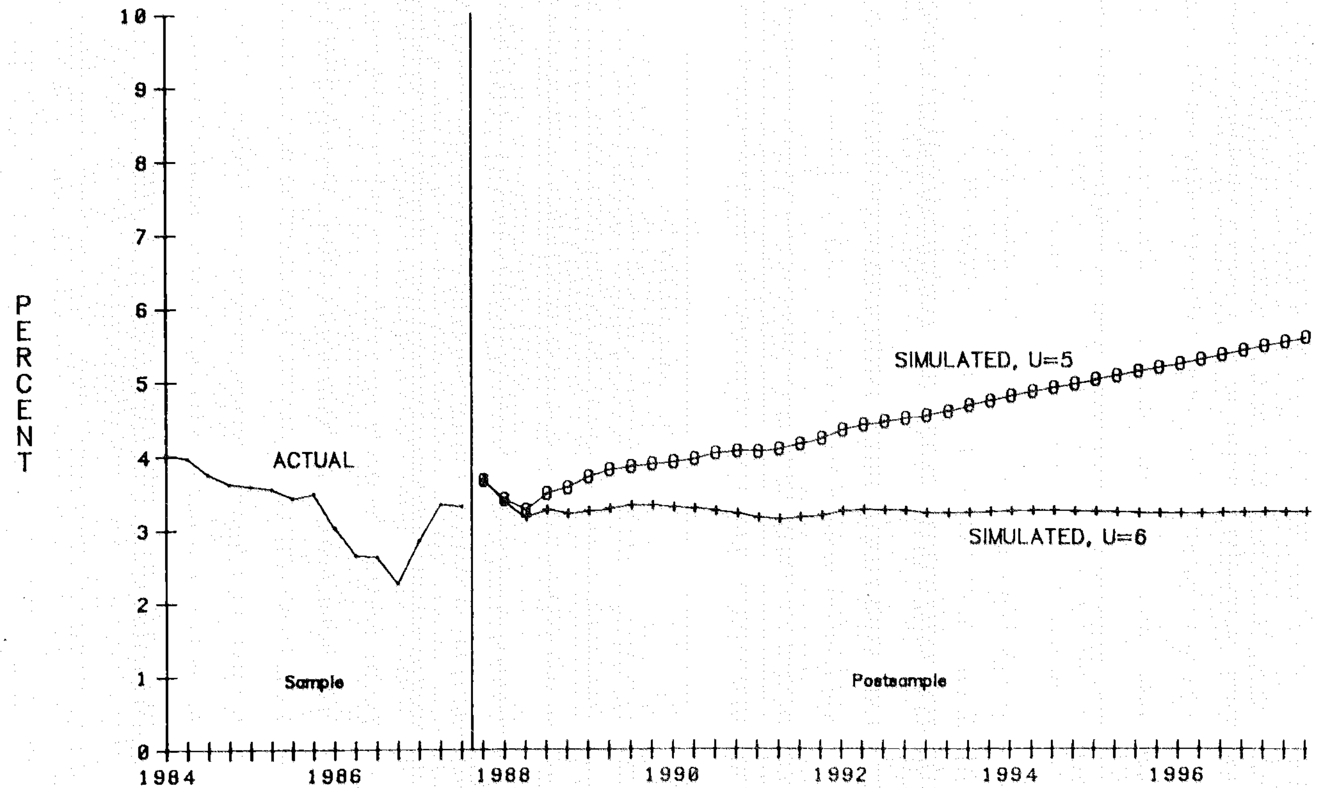
	Hybrid (U^{G*}_t)	Weighted (U^{D*}_t)	Official (U^*_t)
1954-62	5.1	5.0	5.4
1963-68	5.6	5.4	5.4
1968-74	5.8	5.8	5.4
1975-80	5.9	6.3	5.4
1981-87	6.0	5.9	5.4
1987:3	6.0	5.4	5.4

estimation of the natural rate). First, both the official and weighted concepts yield at least one significant intercept shift coefficient in the 1954-87 price equations of Table 6, indicating greater instability in the relationship between price changes and these two natural rate concepts than is the case for the hybrid concept. Second, and more important, using both the ME and RMSE criteria, dynamic simulations for 1981-87 are much more accurate using the hybrid natural rate concept (and its dual, the log output ratio), than using the official or Perry-weighted unemployment rate concepts. Both the latter two concepts, with their estimated 5.4 percent natural unemployment rate for mid-1987, indicate too much slack in the economy and thus tend to generate substantially larger ME and RMSE statistics in the 1981-87 simulations. While the reverse pattern of simulation errors is evident in the labor cost equations, with the hybrid measure generating larger errors, this has implications only for labor's share, not for the natural rate of unemployment which is defined by the criterion of constant inflation.

Given its successful past performance, it is interesting to examine the predictions of the inflation equation for the future with the hybrid natural rate concept.[9] If we make the crucial assumption that all supply-shift variables have effects netting out to zero in the future, we can run dynamic simulations of the price-change equation starting in 1987:4 for two different assumed paths of the unemployment rate. 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. As shown in Figure 4, the 6 percent unemployment path is consistent with steady inflation of 3.5 percent, almost exactly the inflation rate for the four quarters ending in 1987:3. A steady

FIGURE 4

SIMULATED FOUR-QUARTER INFLATION WITH 5 AND 6 PERCENT UNEMPLOYMENT, 1984–97



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.

Some may view this modest acceleration of inflation as a small price to pay for a reduction of unemployment by one 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 acceleration of inflation is to be stopped. Those who would prefer a path of steady inflation can translate the 6 percent unemployment simulation of Figure 4 into 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.

VI. CONCLUSION

Traditionally wage equations of the Phillips curve variety are the central element that explains inflation in large-scale Keynesian econometric models. Price changes are specified as determined by a "mark-up" 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 changes in labor's share. When the labor's share variable is statistically insignificant, as in almost all of the equations estimated in this paper, 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, i.e., 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 1980s has witnessed a "new regime" in wage formation; virtually all of our 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 U. S., e.g., 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 1980s.

However, the puzzle of an increasing and then decreasing income share of labor is irrelevant for the central U. S. policy issue of estimating the natural rate of unemployment, the key measure the measures the amount of slack in the economy available to be eliminated by stimulative policy measures. Since changes in labor's cost (or labor's income share) do not contribute statistically to the price-change equation, only that equation is required to estimate the natural rate. The estimated price-change equations continue to confirm my "hybrid" measure of the natural unemployment rate, which was originally constructed for the 1954-80 period with an allowance for the influence of demographic shifts in the labor force, but which has arbitrarily assumed a fixed natural unemployment rate of 6.0 percent since 1980. This hybrid measure, and its "dual" measure of natural real GNP, perform substantially better in simulation tests for 1981-87 than two alternative natural rate concepts, one estimates the natural rate at 5.4 percent for the entire postwar period, and the other which implies that the natural rate has declined from 6.3 percent on average in 1975-80 to 5.4 percent in mid-1987. Both the latter two concepts yield substantial underpredictions of the inflation rate in the 1981-87 period, i.e., they imply more "slack" (i.e., excess supply) in the economy than has actually occurred. Thus, as of late 1987, there is absolutely no basis to support the conclusion that the natural unemployment rate has fallen below 6 percent. The benign behavior of wage changes merely reflects a decline in labor's share that has not been communicated to price behavior.

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FOOTNOTES

1. The estimate of a natural rate of unemployment rising from 5.0 percent in the mid-1950s to 6.0 percent after the mid-1970s was first presented in Gordon (1982, Appendix B). This time series for the natural rate has emerged as a "consensus" estimate through its presentation in several textbooks (besides mine), articles in business magazines, and because the behavior of inflation in the 1984-86 period seemed roughly consistent with this natural rate series.

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

3. I have previously identified the wage and price equations by omitting the current price variable in the wage equation, while allowing the coefficient on current wages in the price equation to be freely estimated.

4. Blanchard (1987) shows that omitting the current wage or price term makes no difference to the estimates or goodness of fit in monthly data, and we have found in previous work that the same is true of quarterly data.

5. Since my early work for the Brookings Panel in 1971-72, the sample period for the price mark-up equation has always started in 1954:2 rather than 1954:1, because of an erratic jump in the rate of price change in 1954:1. With data revisions and the accumulation of 15 additional years of data, this jump is no longer of any importance, but I maintain the 1954:2 starting date for consistency with past studies.

6. 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) our calculation is based on trend rather than actual productivity, and (2) our wage index refers to the nonagricultural private economy while our price index refers to the total economy.

7. The technique is that identical to that carried out in Gordon (1984). The estimated growth rate of natural output is 2.37 percent per year between 1979:3 and 1987:3, substantially lower than the 2.75 percent rate estimated in (1984). This difference entirely reflects data revisions and the accumulation of three additional years of data, since there is no change in the estimation technique.

8. The importance of the split on the inflation terms in the wage equation also reconciles the results of this paper with those of Gordon (1982), which supported a strong role for prices in the wage equation but displayed only equations in which the lag distribution on prices was split in 1966:4.

9. Here we use the inflation equation appearing in Table 3, column 3, that excludes lagged labor cost but is reestimated to incorporate the restriction that the lagged inflation coefficients sum to unity. Virtually identical results are yielded by the complete price equation in Table 3, column 1.