The Changing Cyclical Behavior of Wages and Prices: 1890–1976

By JEFFREY SACHS*

The persistence of inflation during periods of high unemployment poses the central problem for macro-economic policy in the 1980's. The forecasts of major econometric models for the United States broadly agree that a sustained period of underemployment of resources will be required to markedly reduce the prevailing rate of inflation. Indeed, many economic commentators have surmised that a given level of unemployment now "buys" a smaller reduction in the rate of inflation than in the past. In technical terms, they suggest that the slope of the short-run Phillips curve has declined over time.

In the vast econometric literature on the Phillips relationship, surprisingly little formal analysis has been made of long-term changes in the curve's parameters. Both methodological problems and data limitations make a long-term analysis difficult. Two studies of the secular trend in cyclical wage and price flexibility have recently appeared. The studies use different analytic techniques and reach opposing views on the changing inflation-unemployment tradeoff. In an innovative study of wholesale price behavior in the 1920's and the post-World War II period, Phillip Cagan concludes that "wholesale prices show a smaller decline in the recessions after 1948–49 than formerly," and that "there has clearly been a gradual decline in price response to recessions over the postwar period, except mainly for raw materials prices" (pp. 54–55). Michael Wachter, contrariwise, finds in a study of wages in the post-World War II period that, "a broad range of wage equations reveals the growing cyclical responsiveness of wage inflation" (p.116). The results of course are not directly comparable, for Cagan's focus is on prices while Wachter's is on wages, and the time periods of analysis are different. The discrepancy in conclusions seems to flow, however, from more fundamental differences with the two analyses.

In this paper, two approaches are employed to compare wage and price macrodynamics in the periods 1890–1930 and 1947–76. Both approaches strongly support the hypothesis of a decreasing responsiveness of inflation to changes in aggregate demand. The approach in Section I follows Cagan in analyzing changes in the rates of wage and price inflation from business cycle peaks to troughs. By comparing the decelerations of inflation in pre- and post-World War II recessions of nearly equal magnitude, a rough-and-ready measure of changing price responsiveness is found. In Section II, econometric Phillips curve estimates, akin to Wachter's, are presented. Attention is given to the problems of simultaneous equations bias in standard Phillips curve estimates. A new method of Phillips curve estimation is then described and tested. Not only does the new approach readily yield consistent estimates of the important parameters of the Phillips curve, but it also provides an easy framework for some problems of macro-economic policy.

In Section III, I speculate on the causes for the increase in cyclical wage and price rigidity. It is suggested that two important aspects of the diminishing slope of the short-run Phillips curve are long-term wage agreements and the public's expectations after World War II that monetary and fiscal authorities will intervene to prevent price deflations and unemployment. Theoretical support for these hypotheses is cited, though empirical testing must await further research.

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I

From 1890 to 1976, the American economy experienced nineteen business cycles, as measured by the National Bureau of Economic Research. From 1890 to 1945, fourteen business cycles occurred, and five complete business cycles have transpired since the end of World War II. Following Cagan, simple calculations are made in this section to gauge the responsiveness of wage and price inflation to changes in aggregate economic activity, as indicated by the Bureau cycles. A measure of business cycle severity is used to relate the sizes of wage and price fluctuations to the amplitudes of the cycles.

Modern equations of inflation describe the rate of change of wages and prices according to "equilibrium" and "disequilibrium" components. For some parameter value ϕ, the postulated relationship for wage change at time t is

$$(1) \qquad Dw_t = \phi\left(L_t^d - L_t^s\right) + Dw_t^e \qquad \phi > 0$$

where $Dw_t = (1/w)(dw/dt)$, the time rate of proportional change of wages at time t, L_t^d and L_t^s are the demand and supply of labor, and Dw_t^e is the expected rate of wage inflation. Typically, the excess demand for labor, $L_t^d - L_t^s$, is measured by an adjusted rate of unemployment or other index of aggregate activity. The mechanisms of price change may similarly be specified as $Dp_t = \delta(y_t^d - y_t^s) + Dp_t^e$, where y_t is aggregate output.

Whenever Dw^e or Dp^e is fairly sluggish over a business cycle, a comparison of inflation at the cyclical peak and trough allows us to measure approximately the responsiveness of inflation to disequilibrium market conditions. Simply put, for a constant Dw^e, the change in inflation from peak to trough is given by

$$(2) \quad Dw^p - Dw^t = \phi(L^d - L^s)^p - \phi(L^d - L^s)^t$$

where the superscripts indicate peak and trough. If $Dw^p - Dw^t$ falls over time through successive cycles we may conclude that there is an increasing cyclical rigidity of inflation rates (i.e., a decreasing ϕ) when 1) the successive cycles are of similar amplitude, and 2) Dw^e is invariant over the cycle. When Dw^e varies over the cycle, $Dw^p - Dw^t$ will measure changes both in equilibrium and disequilibrium components.

Let us now turn to the historical evidence, using price and wage indexes for 1890–1929 and 1947–76. Throughout this paper, the period of the Great Depression and World War II are excluded from the analysis. The period of the 1930's is skipped because of well-known perversities in the wage and price dynamics of the period.[1] The years of World War II similarly must be eliminated because of the extensive administrative control of wages and prices during the period. The empirical results displayed in this section are for the *WPI* and indexes of average hourly compensation.[2] The calculations have also been made for a number of other price and wage series, with very similar results. For the sake of brevity, these additional results are not reported, but are available from me upon request.

[1] With unemployment hovering above 20 percent in 1933, prices and wages stopped a four-year fall, and actually began to rise at significant rates. The Wholesale Price Index (*WPI*) rose an average of 6.7 percent per year from 1933 to 1937 while the National Income Accounts wage measure for manufacturing workers increased an average of 5.9 percent per year. Wachter notes that: "...there is evidence that government measures to spur recovery were behind the upward movement in wages. The spurt in the early 1930s is generally attributed to the National Industrial Recovery Act, and Wagner Act and the subsequent growth of unions may have been responsible for that of the late 1930s," (p. 155).

Milton Friedman and Anna Schwartz reach similar conclusions. In accounting for the large rise in the *WPI*, they cite "the explicit measures to raise wages and prices undertaken with government encouragement and assistance, notably, NIRA, the Guffey Coal Act, the agriculture price-support program, and the National Labor Relations Act" (p. 233). Because of these complex institutional changes, the Great Depression is not in the interval of analysis.

[2] Close comparability in wage data for the two periods requires focusing on the manufacturing sector, given data limitations in the earlier period. For the recent period, I have compared Phillips curves estimated with manufacturing sector and economy-wide wages as the dependent variable, finding very little difference in cyclical responsiveness.

TABLE 1—PRICE AND WAGE CHANGES OVER THE BUSINESS CYCLE

		Change, Wholesale Price Index[a]			Change, Compensation Per Hour, Manufacturing[a]		
Year Before Peak to Peak	Peak to Trough	Year Before Peak to Peak (1)	Peak to Trough (2)	(2)−(1)	Year Before Peak to Peak (3)	Peak to Trough (4)	(4)−(3)
1892–93	1893–94	2.2	−10.7	−12.9	4.9	−7.2	−12.1
1894–95	1895–97	2.0	−2.4	−4.4	−3.1	1.3	4.4
1898–99	1899–1900	7.3	7.1	−.2	5.6	1.4	−4.2
1901–02	1902–04	6.4	.6	−5.8	7.3	3.1	−4.2
1906–07	1907–08	4.8	−3.6	−8.4	3.5	−4.9	−8.4
1909–10	1910–11	4.2	−8.3	−12.5	6.2	1.3	−4.9
1912–13	1913–14	1.1	−2.2	−3.3	7.1	−.2	−7.3
1917–18	1918–19	10.9	−5.5	−16.4	27.8	13.0	−14.8
1919–20	1920–21	10.8	−46.0	−56.8	15.0	−12.4	−37.9
1922–23	1923–24	3.9	−2.7	−6.6	10.0	3.3	−6.7
1925–26	1926–27	−3.2	−4.5	−1.3	.9	.9	0.0
1947–48	1948–49	7.9	−5.1	−13.0	8.6[b]	3.1[b]	−5.5[b]
1952–53	1953–54	−1.3	.2	1.5	5.5	4.3	−1.2
1956–59	1957–58	2.8	1.4	−1.4	5.7	4.3	−1.4
1959–60	1960–61	.1	−.4	−.5	3.9	2.9	−1.0
1968–69	1969–70	3.8	3.5	.3	6.3	6.5	.2
1972–73	1973–75	12.3	13.1	.8	7.0	9.9	2.9

Sources: Compensation per hour, 1890–1927, is from the Rees series, expressed in nominal terms. Compensation per hour, 1952–75, is the *BLS* series on Average Hourly Compensation in Manufacturing. For both series, see the Appendix.

Note: Percent Change $\text{Index}_t = \{Log(\text{Index}_t) - Log(\text{Index}_{t-i})\}/i$, where i is the number of years in the interval.

[a]Percent change, annual rate.

[b]For 1947–49, economy-wide compensation per hour is used. The *BLS* series on Average Hourly Compensation in Manufacturing begins in 1950.

Calculations of annual inflation rates are made for seventeen cycles. In Table 1, I report the rates of inflation before and after business cycle peaks for the price and wage series. Under each index, the third column is the difference of the inflation rates from peak to trough of the cycle. The evidence strongly supports the role of aggregate activity on price and wage change. For the *WPI*, the rate of inflation declined during every downturn from 1890 to 1948, and for three of the five recessions after 1948. Wages, similarly, decelerated during every contraction from 1890 to 1961, excluding the 1895–97 period.

In complete accord with Cagan's results for the 1920's, the *WPI* calculations support the hypothesis that prices have become more cyclically rigid over time (though of course I have as yet made no attempt to control for cyclical severity). Almost every contraction from 1890 to 1927 produced a sharper deceleration in price change than did later recessions. Only the deceleration in 1949 is of similar magnitude with the earlier cycles. It is plausible that changing weights in the construction of the *WPI* might account for some of the apparent increase in rigidity. Note, for example, that cyclically flexible agriculture and food prices composed 43.06 percent of the *WPI* in 1926, and only 20.95 percent in 1970. Cagan, for a more limited time period, reestimated the shifts in cyclical inflation using a fixed weighting scheme, and found very little change in the results (pp. 99–100). As a further check, calculations (not shown) were made for the subindex of industrial goods, available from Bureau of Labor Statistics (*BLS*) since 1913. The same perceptible decline in price flexibility is evident.

In Table 1, there is also a discernible trend toward greater cyclical inflexibility of wage change. While nominal wage growth slowed in ten of the eleven cycles before 1930, wage change has in fact accelerated in

TABLE 2—WAGE AND PRICE BEHAVIOR DURING BUSINESS CYCLES: CLASSIFIED BY CYCLICAL SEVERITY, 1890–1976

Peak-Trough	Change in Price Inflation	Change in Wage Inflation	$\Delta GAP \times 100$
Mild Contractions			
1893–94	−12.9	−12.1	−7.5
1895–97	−4.4	4.4	−8.5
1899–1900	−.2	−4.2	−1.7
1910–11	−12.5	−4.9	−8.2
1923–24	−6.6	−6.7	−9.2
1926–27	−1.3	0.0	−3.7
1953–54	1.5	−2.1	−9.7
1960–61	−.5	−1.0	−3.9
1969–70	.3	.2	−8.4
Moderate Contractions			
1902–04	−5.8	−4.2	−11.0
1913–14	−3.3	−7.3	−10.5
1948–49	−13.0	−5.5	−10.2
1957–58	−1.4	−1.4	−11.4
Strong Contractions			
1907–08	−8.4	−8.4	−21.0
1918–19	−16.4	−14.8	−17.4
1920–21	−56.8	−37.4	−25.9
1973–75	.8	2.9	−15.8

Source: Wage and price data from Table 1.

Note: The output gap variable is calculated by regressing *log* (Industrial Production Index) on time and the rate of unemployment. The rate of unemployment is then set at its average value, and fitted values of *log* (Industrial Production Index) are interpreted as trend values. These trend measures are subtracted from actual values, to obtain GAP_t. The calculations were performed separately for the pre- and post-World War II period. The cycles have been grouped by severity, according to ΔGAP, where $\Delta GAP = GAP^p - GAP^t$, the change in GAP from peak to succeeding trough. The grouping is Mild contraction: $-10 \leq \Delta GAP \times 100 \leq 0$; Moderate contraction: $-15 \leq \Delta GAP \times 100 < -10$; Strong contraction: $\Delta GAP \times 100 < -15$.

the last two downturns. Furthermore, the magnitudes of deceleration before 1930 are in general far larger than the measures for 1947–60, where wage change did in fact slow down.

It is important to compare cycles of similar magnitude for testing changes in cyclical wage and price flexibility. Part of the apparent increase in rigidity is due to the relative mildness of most of the post-1945 recessions. The Bureau rankings of business cycle severity exist for 1920–76. I use these rankings as a "benchmark" for a measure covering the entire 1890–1976 period.[3] In particular, a measure of severity is calculated from the percentage deviation of industrial output from its trend value at business cycle peaks and troughs. The change in this output "gap" from peak to trough gauges the amplitude of the cycle. For the years 1920–76, the gap measure and the Bureau severity index yield almost identical rank orderings.

In Table 2, the cycles are arranged according to the gap criterion. The precise classification method is described in the table. The evidence is rather striking. For mild contractions, downward price flexibility seems to have ended with the pre-World War II period. For moderate and severe contractions, similarly, the response of wages and prices has fallen significantly since 1950.

II

The methods of Section I, though convincing in their illustration of a trend toward decreasing cyclical changes in inflation, fail to yield actual estimates of the

[3] See National Bureau of Economic Research, especially *53rd Annual Report* (1973, p. 18).

Phillips curve parameters. It is shown below, however, that traditional econometric attempts to estimate changes in the inflation-unemployment tradeoff may be flawed. In this section, I describe a simple method for obtaining consistent estimates of the Phillips curve coefficients. These estimates add further strong support to the hypothesis of a decline in the short-run Phillips curve slope.

In the standard Phillips curve analysis, (1) is estimated in the form

$$(3)\quad Dw_t=\beta_0+\beta_1 RU_t^{-1}+\beta_2 y(L)Dp_{t-1}+e_t$$

Here, $y(L)$ denotes a polynomial of the lag operator, and RU_t^{-1}, the inverse of the unemployment rate, substitutes for $L_t^d-L_t^s$ in (1). The term RU_t is conventionally entered in inverse form as a reflection of the assumption of a non-linear, decreasing response of inflation to increasing levels of unemployment. Lagged values of the unemployment rate may also be entered. Expected inflation is measured by $y(L)Dp_{t-1}$. The somewhat arbitrary nature of the specification $Dp_t^e=y(L)Dp_{t-1}$ is now well-known, after the justified criticism of rational-expectations theorists.[4] However, for our purposes, the distributed-lag approach may be warranted. In an economy (for example, pre-1930) where the macro-economic structure is not well understood, much less precisely estimated in econometric work, it may be "economically rational" (see Edgar Fiege and Douglas Pearce) to use forecasts of future inflation based upon lagged values of price change. Indeed, when parameter values of structural equations are not known, adaptive or error-learning procedures of forecasting inflation are often optimal forecasting procedures.

Direct estimates of (3) were made for the pre- and post-World War II period, with varying assumptions about the unemployment variable and the structure of $y(L)Dp_t$. All of the regressions reported in this paper use the measure of output gap in industrial production as the disequilibrium variable. For a number of reasons, it is believed that output gap should be preferred to the Lebergott series for pre-1930 labor force unemployment.[5] Various attempts were made to enter lagged values of GAP_t in regression estimates of (3). When GAP_{t-1} was included along with GAP_t, the coefficient of the lagged variable was small and never statistically significant, while the current variable remained significant. When GAP_{t-1} was entered instead of GAP_t, the coefficient was almost always insignificant.

The estimates for (3) are presented in Table 3. All estimates show a large decline in β_1 from the first to the second period, that is, the short-run Phillips curve is flatter in the second period, in conformity with the findings of Section I. In all of the equations, the short-run Phillips curve slope estimate is of the right sign and is statistically significant. For the pre-World War II period, $\hat{\beta}_1$ varies between .4 and .53, while for the post-World War II era, $\hat{\beta}_1$ lies between .07 and .12. The parameter of adaptive expectations in Dp_t^e, λ, is not well measured, and has the wrong sign in regression 3.

In his analysis, Wachter reached very different conclusions regarding the change of β_1 over time. Wachter concluded that the short-run Phillips curve has become increasingly steep. His analysis concerned the 1954–75 period, while the present paper compares the pre-World War II and post-World War II periods, so that the results are not strictly contradictory. Yet it is still worthwhile to ask whether Wachter's methodology might explain the variance of the results. He estimates a modified form of (2):

$$(4)\quad Dw_t=\beta_0+\beta_1 RU_t^{-1}+\beta_2 y(L)Dp_{t-1} +\beta_3 RU_t^{-1}\cdot TIME$$

[4] See, for example, Robert Lucas.

[5] The Lebergott series is subject to large errors. The only available benchmarks for pre-1930 unemployment are the decennial census data of 1900, 1910, and 1920. All other years must be interpolated. Random error in the unemployment rate series would tend to bias toward zero the estimated coefficient on RU_t. Indeed, using an instrumental variable for RU_t substantially increased the magnitude of the unemployment rate coefficient, as would be predicted with errors-in-variables. Importantly, in the regressions I analyzed, the results for shifts in the Phillips curve hold for *both* RU_t and GAP_t as explanatory variables.

TABLE 3—PHILLIPS CURVE ESTIMATION, 1890–1976
(Annual Data)

Period	β_0	β_1	β_2	Dp^e	Post-World War I Dummy Variable	R^2	DW	$\hat{\rho}$
1. 1897–1929	.002 (.24)	.53 (6.4)	constrained to 1	$\lambda=.41$ (4.3)	.057 (2.2)	.71	1.13	
2. 1954–76	.025 (11.4)	.087 (2.72)	constrained to 1	$\lambda=.54$ (5.66)		.99	1.62	
3. 1897–1929	.013 (1.9)	.40 (5.56)	.49 (5.56)	$\lambda=-.40$ (3.48)	.09 (4.1)	.79	1.19	
4. 1952–76	.020 (3.38)	.071 (1.65)	1.19 (5.61)	$\lambda=.59$ (5.86)		.99	1.85	
5. 1894–1929	.019 (1.48)	.43 (5.34)	$\sum_{1}^{3}\lambda_i=.46$		.07 (3.23)	.79	1.76	.14 (3.45)
6. 1952–76	.02 (5.78)	.114 (3.53)	$\sum_{1}^{3}\lambda=1.14$			.997	1.88	−.35 (1.88)

Notes: The dependent variable is percentage change in Average Hourly Compensation in Manufacturing, as described in Table 1. The variable GAP_t is used in place of RU_t^{-1} shown in (2), for reasons described in Section II. In regressions 1–4,

$$Dp_t^e=(1-\lambda)\sum_{i=0}^{3}\lambda^i Dp_{t-q-i}+\lambda^4 Dp_{-5}$$

where Dp_t is the percentage rate of change of the *GNP* deflator, described in the Appendix. In regressions 5–6, three lagged values of Dp were entered in unconstrained form as the measure of Dp_t^e. The Post-World War I Dummy Variable is included to account for the massive deflation of 1921. Post-World War I Dummy = 1 in 1919 and 1920, and −1 in 1921. Regressions 1–4 were estimated using non-linear squares. Regressions 5–6 were estimated with the Cochrane-Orcutt correction for serial correlation, given by $\hat{\rho}$. The numbers in parentheses are t-statistics.

Since $dDw_t/dRU_t^{-1}=(\beta_1+\beta_3\cdot TIME)$, Wachter avers that a positive β_3 should indicate a secularly increasing responsiveness of inflation to unemployment, while a negative β_3 should prompt the reverse conclusion. For 1954:I to 1975:II, he finds $\hat{\beta}_3>0$. Wachter errs, however, in letting only the coefficient on RU^{-1} change over time. If, in the true model, either β_0 or β_2 but *not* β_1 increases over time, then estimating (4) will tend to give an upward biased estimate of β_3.[6] In fact, it is far more likely that β_2, the coefficient on the distributed lag on prices, has been increasing while β_1 has been falling. I show below the results of estimating Wachter's equation, without β_3, for different terminal dates. It seems clear that β_1 has not significantly increased, when analyzed by a method that allows all parameters to change:[7]

Time Period	$\hat{\beta}_1$	$\hat{\beta}_2$
1954:I–1965:IV	.024 (1.3)	.31 (.58)
1954:I–1968:IV	.017 (1.9)	.31 (.71)
1954:I–1976:IV	.011 (2.1)	.87 (5.11)

[6] Suppose, for example, that the curve's intercept but not slope has been increasing over time, so that $Dw_t=\beta_0+\lambda_1 TIME+\beta_1(RU^{-1})_t+\beta_2 y(L)Dp_{t-1}, \lambda_1>0,$ is the true model. If equation (4) is estimated instead, it is easily shown that $plim(\beta_3)=\lambda_1 reg(TIME, GAP\cdot TIME|y(L)Dp_{t-1}, RU_t^{-1})$, where the term $reg(\cdot)$ is the multiple regression coefficient of $GAP\cdot TIME$ in a regression of $TIME$ on $GAP\cdot TIME$, $y(L)Dp_{t-1}$, and RU_t^{-1}. Thus, the estimate of β_3 would tend to be positive even though β_3 is in fact zero.

[7] The equation $Dw_t=\beta_0+\beta_1 RU_t^{-1}+\beta_2 y(L)Dp_{t-1}$ is estimated for quarterly data. The term w_t is the average hourly earnings in manufacturing; RU_t is the unemployment rate for males age 25+; p_t is the nonfarm deflator, and $y(L)$ is a third-degree polynomial distributed lag of length sixteen quarters, unconstrained at both ends.

The estimates that we have so far examined in Table 3 and Wachter's estimates may be marred by a bias introduced in regressing wage changes on price changes. Most current econometric price equations confirm that prices are well described as markups over standard unit labor costs. Price changes approximately equal wage changes less trend productivity growth, Dq^t. Rewriting (3) with $Dw_{t-1} - Dq^t = Dp_{t-1}$, we have

$$(5)\qquad Dw_t = (\beta_0 - \beta_2 Dq) + \beta_1 RU_t^{-1} + \beta_2 y(L) Dw_{t-1} + e_t$$

Now, if the e_t is a serially correlated process, $y(L)Dw_{t-1}$ will be correlated with e_t, and estimates of (5) will be biased. One standard method for dealing with this problem is to assume a particular form for the process e_t, and to make maximum likelihood estimates for (5) using the process explicitly. This approach is taken in equations (5)–(6) of Table 3, where it is assumed that $e_t = \rho e_{t-1} + u_t$, and u_t is independently, identically distributed. Note that $\hat{\rho}$ is statistically significant in both of these equations. With the autocorrelation correction, β_1 remains larger in the earlier period.

There is no particular reason beyond convenience to postulate this specific autoregressive process. With three standard assumptions, however, it is possible to skirt the statistical difficulties of the usual analysis. The assumptions of 1) adaptive inflationary expectations, 2) no long-run inflation-unemployment tradeoff, and 3) prices as markups over standard unit labor costs, lead to the following simple model (writing GAP_t for RU_t^{-1}):

$$(6)\qquad Dw_t = \beta_0 + \phi(GAP)_t + Dp_t^e + e_t$$

$$(7)\qquad Dp_t^e = (1-\lambda)Dp_t + \lambda Dp_{t-1}^e$$

$$(8)\qquad P_t = (1+m)SULC \quad \text{(standard unit labor cost)}$$

If trend labor productivity growth is at a constant rate Dq, then (8) may be rewritten as $Dp_t = Dw_t - Dq^t$. Notice that (7) may be rewritten as $Dp_t^e = (1-\lambda)\,Dp_t/(1-\lambda L)$. Using this expression with (6) and (8) we may derive

$$(9)\qquad Dw_t - Dw_{t-1} = \Delta Dw_t = \frac{(1-\lambda)(\beta_0 - Dq)}{\lambda} + \frac{\phi}{\lambda} GAP_t - \phi GAP_{t-1} + \frac{e_t}{\lambda} - e_{t-1}$$

Through a transformation of (6) we have thus been able to eliminate the lagged wage terms from the estimated equation. Under the assumption that GAP_t is exogenous, the estimation of (9) by maximum liklihood or ordinary least squares will give consistent estimates of the parameters. Finally, note that we may find the "natural rate" of the output gap by setting $\Delta Dw_t = 0$, and $GAP_t = GAP_{t-1}$. We find $GAP^{NR} = (\beta_0 - Dq)/-\phi$. The equation to be estimated becomes

$$(10)\qquad \Delta Dw_t = \frac{-\phi}{\lambda}(1-\lambda)GAP^{NR} + \frac{\phi}{\lambda} GAP_t - \phi GAP_{t-1} + \frac{e_t}{\lambda} - e_{t-1}$$

How plausible are the assumptions underlying the present model? Equation (10) suggests an historical consistency check of the model. We can see from (10) that $(GAP_t - GAP_{t-1}) > (1-\lambda)(GAP^{NR} - GAP_{t-1})$ implies ΔDw and $\Delta Dp > 0$. Thus, whenever aggregate activity is rising (i.e., $GAP_t - GAP_{t-1} > 0$) *and* employment or output in period $t-1$ is above the equilibrium level, inflation should intensify ($\Delta Dw > 0$). By similar argument, whenever output is below its long-run equilibrium level, and output is falling, inflation should be decelerating. In eleven of the years since 1893, the economy experienced increasing output relative to potential during a period of already high employment ($GAP_{t-1} > GAP^{NR}$). In ten of these years, wage inflation accelerated as predicted. In nine years of the periods 1893–1929 and 1948–75, the economy was characterized by low and falling levels of aggregate activity. In six years, wage inflation showed a declining rate.[8] The accelerationist property is justified.

[8]In years 1894, 1896, 1900, 1921, 1960, 1961, 1971, 1974, and 1975, $GAP_t < GAP_{t-1} < 0$. In six of nine years, wage inflation decelerated as expected: 1894, 1900, 1921, 1960, 1961, and 1971. In years 1902, 1906,

TABLE 4—PHILLIPS CURVE ESTIMATION, 1893–1975, EQUATION (11)

Period	Dependent Variable	$\hat{\phi}$	$\hat{\lambda}$	$G\hat{A}P^{NR}$	Post-World War I Dummy Variable	SE	DW
1894–1926	ΔDw_t^a	.50	.63	.02	.10	.049	1.92
		(5.36)	(5.82)	(.93)	(3.42)		
1895–1929	ΔDw_t^b	.36	.53	.014	.015	.053	2.19
		(3.57)	(3.88)	(.51)	(.48)		
1895–1929	ΔDw_t^d	.31	.68	.033	.087	.048	2.13
		(3.58)	(3.42)	(.57)	(3.03)		
1950–75	ΔDw_t^a	.14	1.31	.06		.012	2.26
		(2.80)	(2.83)	(.53)			
1952–75	ΔDw_t^b	.038	4.37	.011		.015	1.94
		(.53)	(.16)	(.098)			
1950–75	ΔDw_t^c	.13	.997	−3.03		.014	2.47
		(2.14)	(2.48)	(.06)			
1950–75	ΔDp_t^d	.026	.41	−.10		.018	2.08
		(.32)	(.38)	(.51)			

Notes: For all data, see descriptions in Appendix; $\Delta DX_t = (log X_t - log X_{t-1}) - (log X_{t-1} - log X_{t-2})$, SE is standard error of the regression. All regressions use non-linear least squares estimation.
[a] w_t is Average Hourly Earnings in Manufacturing.
[b] w_t is Average Hourly Compensation in Manufacturing.
[c] w_t is Average Hourly Compensation, economy wide.
[d] p_t is GNP Deflator.

Equation (10) may be estimated by ordinary least squares (OLS) or by a maximum likelihood procedure (non-linear least squares (NLS)). With OLS we estimate:

$$(11) \quad \Delta Dw_t = \zeta_0 + \zeta_1 GAP_t + \zeta_2 GAP_{t-1} + \mu_t$$

Using the estimates ζ_1 and ζ_2 we may obtain consistent estimates of the underlying parameters ϕ and λ. Note that $plim(\hat{\zeta}_2) = -\phi$, and $plim(-(\hat{\zeta}_2/\hat{\zeta}_1) = -plim(\hat{\zeta}_2)/plim(\hat{\zeta}_1) = \lambda$. In addition, since $\zeta_0 = (-\phi/\lambda)(1-\lambda)GAP^{NR}$, we can also obtain a consistent estimate of GAP^{NR}. By use of the Fieller Bound technique, confidence intervals may be calculated for the point estimates of the underlying parameters (see Zvi Griliches, pp. 32-33). With NLS we may directly estimate the underlying parameters of the model.[9] Because (11) is exactly identified, that is, there is a one-to-one mapping from $(\zeta_0, \zeta_1, \zeta_2)$ to $(GAP^{NR}, \phi, \lambda)$, the OLS and NLS estimates of the underlying parameters are identical.

Table 4, presents a summary of estimates of the model. The results are encouraging. In all of the regressions, the coefficients are of expected sign, and are usually statistically significant. In general, the estimates of ϕ are close to the estimates of β_1 shown in Table 3; again, ϕ declines substantially from the first period to the second. The estimation of Table 4 was made for additional time periods and different wage and price indexes, with little change in the results. For all of the regressions, we cannot reject the hypothesis that $GAP^{NR}=0$. This is an appealing result. Because GAP_t is constructed as a measure of the deviation of output from trend, the result suggests that the long-run equilibrium value of output (GAP^{NR}) is equal to its trend value. On average, over extended periods, the economy is in equilibrium. Note, finally, that there is a little evidence that λ has increased over time. If so, the mean lag of past inflation in forecasts of future inflation $(\lambda/1-\lambda)$ has also lengthened over time. While λ is a crucial parameter for macro-economic policymaking, as shown below, it is not precisely estimated by the equations of Table 4.

1910, 1913, 1916, 1926, 1929, 1951, 1953, 1966, and 1968, $GAP_t > GAP_{t-1} > 0$. In all but one year (1953), wage change increased as predicted.

[9] Note that u_t in (11) is equal to $e_t/\lambda - e_{t-1}$, from (11). There is no more nor less reason to believe that u_t is identically independently distributed (*iid*) than to believe that e_t is *iid*. The coefficient estimates from NLS (or OLS) regression of (12) will be consistent whether or not u_t is *iid* though efficiency, and consistency of the estimates of the standard errors require that u_t be *iid*.

If ϕ and λ can be considered as exogenous to the policymaker (the discussion of Section III indicates that ϕ and λ change with varying macro-economic policies), we can describe some effects of the shifts of the Phillips curve for policy by a simple formula. Consider a convenient (and highly stylized) one-parameter description of policy. For any output GAP_{t_0} in year t_0, policymakers choose $\delta \cdot GAP_{t_0}$ as their output target in year t_1. Appropriate monetary and fiscal policies are followed so that a constant proportion $(1-\delta)$ of the deviation of output from its equilibrium is removed each year. Then it can be shown that:[10]

(12)

$$Dp(\text{steady state}) = Dp_{t_0} + \frac{\phi GAP_{t_0}(\delta-\lambda)}{\lambda(1-\delta)}$$

Thus, starting in a recession ($GAP_{t_0} < 0$), the following conditions imply a high steady-state rate of inflation: 1) a rapid recovery (low δ); 2) long lags in expectations (high $-\lambda$); and 3) a low short-run Phillips curve slope (small ϕ). Given the estimates of falling ϕ and rising λ, we can understand the policy difficulty of recovering from the 1974–75 recession.

Two further points are worthy of mention. First, the path of constant inflation is followed by setting $\delta = \lambda$, as shown in equation (12). The magnitude of the short-run Phillips curve slope is completely irrelevant in determining this path, under assumptions of adaptive expectation! Second, while a low Phillips curve slope and long lags in expectations are very undesirable during recessions, these conditions are *most* desirable during booms. A low slope and long mean lag permit an economy to operate with output in excess of the natural rate for an extended period without a serious acceleration of inflation. Wachter has offered evidence of precisely this phenomenon. Since 1950, Wachter argues, there is a continuing pattern of "smaller first-year upward responses of wages to tight market conditions" (p. 153).

In interpreting (12) it has been assumed that ϕ is independent of the policy parameter δ. In fact, changes in δ over long periods of time may be a major source of long-term movements of ϕ. As will be shown in the next section, the Phillips curve may not be invariant to policy choices; and with ϕ a function of δ, (12) would not be the true "policy menu."

III

We have thus far seen how the parameters of the Phillips curve have changed over time, and how these changes have implications for economic policy. Our understanding of inflation-unemployment interactions would be considerably enhanced by a detailed historical discussion of how and why these changes emerged. Unfortunately, given the immense structural shifts that have characterized the *U.S.* economy since 1900, the historical exegesis is a large task, and one that is beyond the scope of this paper. Complex changes in product and labor markets, such as increasing concentration, higher ratios of value-added per shipment, increased unionization, and the large increases in investment in human capital, have all played a role in the decreased cycli-

[10] For a policy rate δ, we can easily calculate the steady-state conditions for an initial GAP and rate of inflation. Since $Dp_t - Dp_{t-1} = (\phi/\lambda)GAP_t - \phi GAP_{t-1}$ (from (11) setting $e_t = e_{t-1} = GAP^{NR} = 0$):

(a)

$$\sum_{t=1}^{T}(Dp_t - Dp_{t-1}) = \sum_{t=1}^{T}\left(\frac{\phi}{\lambda}GAP_t\right) - \sum_{t=1}^{T}\phi GAP_{t-1}$$

But $GAP_t = \delta^t GAP_{t0}$, by assumption. Replacing this relation in equation (a) we find

(b)

$$\sum_{t-1}^{T}(Dp_t - Dp_{t-1}) = \frac{\phi}{\lambda}GAP_{t0}\sum_{t=1}^{T}\delta^t - \phi GAP_{t0}\sum_{t=0}^{T-1}\delta$$

or, simplifying,

(c)

$$Dp_T - Dp_0 = \frac{\phi}{\lambda}GAP_{t0}\cdot\frac{(\delta-\delta^{T+1})}{(1-\delta)} - \phi GAP_{t0}\frac{(1-\delta T)}{(1-\delta)}$$

To find the steady-state condition, take the limit with respect to T of (c), and rearrange:

$$Dp_{ss} = Dp_{t0} + \frac{\phi GAP_{t0}(\delta-\lambda)}{\lambda(1-\delta)}$$

cal response of wage and price inflation. In this section I shall discuss two less analyzed, though probably very important, contributors to the Phillips curve shift.

First, the emergence of countercyclical macro-economic policy since World War II has probably changed the cyclical behavior of wage and price setters. Martin Baily has recently argued that growing expectations of countercyclical macro-economic policy have smoothed the cyclical adjustments of production and employment in the private sector. It is also likely that such expectations have smoothed the cyclical movements of wages and prices. I have demonstrated this theoretically in my earlier paper, and will outline the main argument below.

A second source of cyclical rigidity is probably the spread of long-term explicit and implicit contracts. It is well-known that union wages are less responsive cyclically than nonunion wages (compare H. Gregg Lewis, Robert Flanagan). The usual explanation points to the use of long-term wage agreements in the union sector. Over my period of study, unionization has spread dramatically, as has the average duration of collective bargaining agreements. This trend could well result in secular increases in aggregate wage rigidity. Note that the spread of long-term contracts might itself result from the stability engendered by active macro-economic policy.

One explanation of the Phillips curve is that workers cut wages when there is high unemployment because of the expectation of continued low demand for labor, at given nominal wages, in the future. To the extent that countercyclical policy breaks the link between current unemployment and the expectation of continuing low aggregate (nominal) demand, today's unemployment will not induce wage cuts in contracts for succeeding periods. In a model of macroeconomic response to a supply shock, Edmund Phelps has succinctly stated this view:

> Suppose that wage setters expect the central bank to accommodate the supply shock by adjusting the money supply and thus the price level in such a way as to hold invariant the quantity of labor that will be demanded by firms at the pre-existing money wage W_0.... If they know they hold these beliefs in common, then their "rational expectation" is that the pre-shock money wage will equilibrate the labor market as it did before the shock. Each firm will expect the other firms to maintain their wages and it will do the same. [p. 209]

In Phelps' case, the slope of the short-run Phillips curve is zero, for unemployment does not induce any wage deflation.

In a more general model of wage setting in the presence of activist policy, I have shown that the slope of the statistical Phillips curve depends on 1) the extent of countercyclical policy, and 2) the degree to which unanticipated changes in the money stock are countered by the monetary authority in succeeding periods.[11] Simple regressions describing money supply growth indicate that both supply characteristics have changed in the direction tending to reduce the Phillips curve slope.[12] In the period 1895–1929 there is no evidence of a countercyclical response of the money supply. For 1952–75, the regression indicates that the money stock is raised 1 percent above trend in the year following a 10

[11] Condition 1) is described by Phelps. Condition 2) results from the fact that any period's GAP_t is in part due to unexpected movements of the money stock, M_t. If M_t falls below anticipated levels, output will drop. The decline in M_t reduces expectations of future full-employment nominal wages only if the shortfall is permanent (i.e., as long as the central bank does not act to "correct" the shortfall in M_t by reflating next period). To the extent that the drop in money growth is not counteracted, $GAP_t < 0$ will be followed by a reduction in $w_{t+1} - w_t$.

[12] The regressions relate money growth to lagged money growth and lagged output gap, in an equation similar to Robert Barro's. For $\Delta M_t = \alpha_0 + \alpha_1 \Delta M_{t-1} + \alpha_2 \Delta M_{t-2} + \alpha_3 \Delta M_{t-3} + \alpha_4 GAP_{t-1} + u_t$, $u_t = \rho u_{t-1} + e_t$ we find

	α_0	α_1	α_2	α_3	α_4	ρ	R^2
1895–1929	.07	−.31	−.11	.27	06	.17	.605
	(2.54)	(1.4)	(.62)	(1.6)	(.42)	(1 02)	
1952–75	.09	.55	−.20	.56	−.11	−.53	.49
	(1.05)	(2.45)	(.82)	(2.78)	(1.48)	(2.99)	

where ΔM_t is $log(M_2)_t - log(M_2)_{t-1}$, for the M_2 definition of the money stock. Sources of M_2 are given in the Appendix.

percent industrial output shortfall, and more in following years. Moreover, there is evidence of significant *negative* serial correlation in the residuals of the money supply equation for 1952–75, suggesting that monetary authorities now act to correct partially for unexpected money movements.

The presence of long-term contracts fixing nominal wage growth also reduces the short-run response of aggregate wages to cyclical fluctuations, for two reasons. Most directly, wages fixed by earlier contract may be unable to react at all in the short-term to current, unexpected cyclical developments. This phenomenon is clearly evident in Flanagan's recent study of union-nonunion wage differentials. Comparing the contract (union) sector with the noncontract sector, Flanagan writes:

> That differences in the cyclical sensitivity of average union and non-union wage changes exist is clear in the postwar data. However, it is also clear that first year negotiated wage changes are almost as sensitive to labor market pressures as non-union wages. *Most of the inertia in negotiated wages is a by-product of multi-year labor agreements.* [p. 673, emphasis added]

Second, I have shown in my earlier paper that wages determined in the *noncontract* market (assumed to clear continuously) will show smaller cyclical fluctuations the larger is the sector of labor covered by long-term agreements. Basically, the larger is the contract sector the smaller is the aggregate price disturbance transmitted to the noncontract sector following an aggregate demand shock. The disturbance is absorbed in output fluctuations in the contract sector rather than in aggregate price fluctuations. Assuming that the noncontract labor market is cleared at a given real wage, the reduced aggregate price fluctuations result in smaller wage fluctuations in that sector. These results depend on low intersectoral mobility of labor over the cycle.

Thus the tremendous increase in duration and coverage of collective bargaining agreements are probably important forces behind the Phillips curve shift between the two periods. As late as 1948, the great majority of all wage agreements were of one year duration; by 1972, most contracts were written for three years.[13] And the contracts now cover a larger portion of the work force. In the manufacturing sector, for instance, only 11.6 percent of production workers were organized in 1910, while by 1973, approximately 49 percent of manufacturing production employees were organized by labor unions. Economy wide, 5.8 percent of the civilian labor force belonged to unions in 1910, while 23.4 percent belonged in 1970.[14]

The two explanations for increasing cyclical wage rigidity, activist macro-economic policy and long-term contracts, are complements rather than strict alternatives. Indeed, when extensive empirical tests of these and other hypotheses are carried out, a range of explanations will surely be necessary to account for the important changes in cycle behavior that are documented in Sections I and II of this paper. Given the crucial importance of the Phillips curve slope for macro-economic policy, as suggested at the end of the last section, this research should soon be undertaken.

[13]The classification of union labor agreements by contract duration yields the following percentage breakdown for 1948 and 1972:

Duration in Years	1948	1972
1	.75	.02
1–2	.10	.15
2^{+}–3		.11
3; 3^{+}	.15	.57

The 1948 data are from Wladimir Woytinsky and the 1972 data are from *Characteristics of Agreements Covering 1,000 Workers or More.*

[14]Union membership in the manufacturing sector, 1910, is from Leo Wolman. Data for 1973 are found in Richard Freeman and James Medoff (p. 44). The economy-wide percentage union membership is calculated by dividing Series D952 by Series D4 and D14 in *Historical Statistics of the United States.* Note that while duration increased *within* the 1950–76 period, the percentage of the manufacturing labor force covered by collectively bargained agreements declined slightly. According to data in Freeman and Medoff (p. 44), 67 percent were covered in 1958 and 61 percent in 1973–75. Of course, the arguments concerning the spread of coverage apply only to interperiod comparisons.

APPENDIX—DATA SOURCES

Wage Data

1. Compensation per Hour, Manufacturing—1890–1945: Series B72 of *Long-Term Economic Growth, 1860–1965*. The Rees time-series is expressed in constant 1957 dollars. To get nominal wages, the wage series was multiplied by the *CPI*, Series E 135 in *Long-Term Economic Growth, 1860–1965*. 1950–76: Hourly compensation in manufacturing, found in *BLS* (1978).

Comparisons of wage behavior were made for other series as well. In particular, the results of the paper were consistently verified for:

2. Average Hourly Earnings in Manufacturing—1890–1926: Series D 769-770 of *Historical Statistics of the United States*, developed by Paul Douglas. 1950–1976: Average Hourly Earnings, Manufacturing Sector, *BLS* (1977, p. 81).

The behavior of the economy-wide wages was studied in the current period using Series 745 in *Business Conditions Digest*. This series, "Average Hourly Compensation, All Employees in Private Nonfarm Economy," was found to behave cyclically quite closely with the two recent series in manufacturing given above.

Price Data

1. *GNP* Deflator—1890–1945: Series B62, *Long-Term Economic Growth, 1860–1965*. 1948–76: Series 310, *Business Conditions Digest*.

2. Wholesale Prices—1890–1945: Series B69, *Long-Term Economic Growth, 1869–1965*. 1948–76: Series 330, *Business Conditions Digest*.

Industrial Production—1890–1945: Series A15, *Long-Term Economic Growth, 1860–1965*. 1948–76: Series 47, *Business Conditions Digest*.

Unemployment Rate, All Civilian Workers—1890–1929: Series B1, *Long-Term Economic Growth, 1860–1965*. 1945–76: Series 43, *Business Conditions Digest*.

Money Stock M_2—1890–1929: Series X415, *Historical Statistics of the United States*. 1945–76: Series 102, *Business Conditions Digest*.

REFERENCES

M. N. Baily, "Stabilization Policy and Private Economic Behavior," *Brookings Papers*, Washington 1978, *1*, 11–50.

R. J. Barro, "Unanticipated Money, Output, and the Price Level in the United States," *J. Polit. Econ.*, Aug. 1978, *86*, 549–79.

P. Cagen, "Changes in the Recession Behavior of Wholesale Prices in the 1920's and Post-World War II," *Explor. Econ. Res.*, Winter 1975, *2*, 54–104.

E. Feige and D. Pearce, "Economically Rational Expectations," *J. Polit. Econ.*, June 1976, *84*, 499–522.

R. J. Flanagan, "Wage Interdependence in Unionized Labor Markets," *Brookings Papers*, Washington 1978, *3*, 635–73.

R. Freeman and J. Medoff, "New Estimates of Private Sector Unionism in the United States," Nat. Bur. Econ. Res. disc. paper no. 273, Cambridge, Mass., Aug. 1978.

Milton Friedman and Anna Schwartz, *A Monetary History of the United States, 1867–1960*, Princeton 1963.

Z. Griliches, "Distributed Lags: A Survey," *Econometrica*, Jan. 1967, *35*, 16–49.

H. Gregg Lewis, *Unionism and Relative Wages in the United States*, Chicago 1963.

R. Lucas, "Econometric Testing of the Natural Rate Hypothesis," in Otto Eckstein, ed., *The Econometrics of Price Determination*, Washington 1972.

E. Phelps, "Commodity-Supply Shocks and Full-Employment Monetary Policy," *J. Money, Credit, Banking*, May 1978, *10*, 206–21.

J. Sachs, "A Note on the Phillips Curve and Countercyclical Macroeconomic Policy," unpublished manuscript, 1978.

M. Wachter, "The Changing Cyclical Responsiveness of Wage Inflation," *Brookings Papers*, Washington 1976, *1*, 115–68.

Leo Wolman, *The Growth of American Trade Unions, 1880–1923*, New York 1924.

Wladimir S. Woytinsky, *Employment and Wages in the United States*, Baltimore 1953.

National Bureau of Economic Research, *Annual Report*, New York, various issues.

U.S. Bureau of the Census, *Business Condi-*

tions Digest, Washington, various issues.

______, *Historical Statistics of the United States, Colonial Times to 1970*, Washington 1976.

______, *Long-Term Economic Growth, 1860–1965*, Washington 1966.

U.S. Bureau of Labor Statistics, (*BLS*) *Characteristics of Agreements Covering 1000 Workers or More, July, 1972*, Washington 1972.

______, "Output Per Hour, Hourly Compensation and Unit Labor Costs in Manufacturing, Eleven Countries, 1950–1977," Washington, May 1978.

______, *Handbook of Labor Statistics*, Bull. 1966, Washington 1977.