THE CHANGING CYCLICAL BEHAVIOR
OF WAGES AND PRICES: 1890-1976

Jeffrey Sachs

Summary

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The persistence of inflation during periods of high unemployment poses
the central problem for macroeconomic policy in coming years. The extent of
success in reducing both inflation and unemployment will depend strongly on
the short-run responsiveness of wage inflation to unemployment and excess
capacity. This paper studies changes in the cyclical responsiveness of
inflation from 1890-1976, and concludes that a given shortfall in production
relative to potential now "buys" a smaller reduction in the rate of inflation
than in the past. From 1890-1929, a one percent decline in industrial
production reduced inflation about .45%; for 1950-1976, the same output
decline is estimated to slow inflation only about .1%.

The analysis makes use of two methods to study the changing cyclical
behavior of inflation. Following an innovative study by Cagan, calculations
are made for wage and price inflation before and after eighteen business
cycle peaks. While inflation slows in almost every recession, the declines
in inflation in recent years are less pronounced than earlier, even when
controlling for business cycle severity. In a second section of the study,
econometric evidence is provided that also strongly supports the hypothesis
of increasing rigidity of wage and price inflation over the business cycle.

In the last section of the paper, some possible reasons are cited
for the declining responsiveness of inflation to unemployment. Ironically,
successful macroeconomic policy might be in part responsible. To the extent
that activist macroeconomic policy breaks the link between current unemployment
and expectations of future unemployment, it is argued, unemployment today will
not induce wage cuts in contracts for future periods. Also, the tremendous
increase in duration and coverage of collective bargaining agreements is
suggested as an important force behind the shifting behavior of wages and
prices during the period of study.

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The persistence of inflation during periods of high unemployment
poses the central problem for macroeconomic policy in the 1970s. The
forecasts of major econometric models for the U.S. 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 1920s and the post-
World War II period, Cagan [3] 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."[1]
Wachter [17], 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."[2] 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 1947-1976. 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 macroeconomic policy.

In Section III, we speculate on the causes for the increase in cyclical wage and price rigidity. We suggest 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.

I

From 1890 to 1976, the American economy experienced 19 business
cycles, as measured by the N.B.E.R. From 1890 to 1945, 14 business
cycles occurred, and 5 complete business cycles have transpired since
the end of World War II. Following Cagan, simple calculations are
made in this section of the paper to gauge the responsiveness of wage
and price inflation to changes in aggregate economic activity, as
indicated by the N.B.E.R. 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 relation-
ship for wage change at time t is:

$$(1) \quad \dot{w}_t = \phi \ (L_t^d - L_t^s) + \dot{w}_t^e, \ \phi > 0$$

where $\dot{w}_t = \frac{1}{w} \frac{dw}{dt}$, 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 $\dot{w}_t^e$ 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 $\dot{p}_t = \delta \ (y_t^s - y_t^s) + \dot{p}_t^e$, where y_t is
aggregate output.

Whenever $\dot{w}^e$ or $\dot{p}^e$ 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 $\dot{w}^e$, the change in inflation from peak to trough is given by

$$(2) \quad \dot{w}^P - \dot{w}^t = \phi \, (L^d - L^s)^P - \phi \, (L^d - L^s)^t$$

(where the superscripts indicate peak and trough). If $\dot{w}^P - \dot{w}^t$ 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) $\dot{w}^e$ is invariant over the cycle. When $\dot{w}^e$ varies over the cycle, $\dot{w}^P - \dot{w}^t$ will measure changes both in equilibrium and disequilibrium components.

We now turn to the historical evidence, using price and wage indexes for 1890-1929 and 1947-1976. Throughout this paper, the period of the Great Depression and World War II are excluded from the analysis. The period of the 1930s is skipped because of well-known perversities in the wage and price dynamics of the period.[3] 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 wholesale price index (WPI) and indexes of average hourly compensation.[4] 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 the author.

Calculations of annual inflation rates are made for seventeen

cycles. In Table 1, we 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 1895-1897 period.

In complete accord with Cagan's results for the 1920s, the WPI
calculations support the hypothesis that prices have become more
cyclically rigid over time, (though of course we 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% of the WPI in 1926, and only
20.95% in 1970. Cagan, for a more limited time period, re-estimated
the shifts in cyclical inflation using a fixed weighting scheme, and
found very little change in the results.[5] As a further check,
calculations (not shown) were made for the sub-index of industrial
goods, available from 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

TABLE 1

PRICE AND WAGE CHANGES OVER THE BUSINESS CYCLE

Year Before Peak to Peak	Peak to Through	% Δ Wholesale Price Index Year Before Peak to Peak (1)	(Ann. Rate) Peak to Through (2)	Δ (2)-(1)	% Δ Compensation Per Hour Year Before Peak to Peak (3)	Peak to Through (4)	Manufacturing Δ (4)-(3)
1892-1893	1893-1894	2.2	-10.7	-12.9	4.9	-7.2	-12.1
1894-1895	1895-1897	2.0	- 2.4	- 4.4	-3.1	1.3	4.4
1898-1899	1899-1900	7.3	7.1	- .2	5.6	1.4	-4.2
1901-1902	1902-1904	6.4	.6	- 5.8	7.3	3.1	-4.2
1906-1907	1907-1908	4.8	-3.6	- 8.4	3.5	-4.9	-8.4
1909-1910	1910-1911	4.2	-8.3	-12.5	6.2	1.3	-4.9
1912-1913	1913-1914	1.1	-2.2	- 3.3	7.1	-.2	-7.3
1917-1918	1918-1919	10.9	-5.5	-16.4	27.8	13.0	-14.8
1919-1920	1920-1921	10.8	-46.0	-56.8	15.0	-12.4	-37.9
1922-1923	1923-1924	3.9	-2.7	- 6.6	10.0	3.3	-6.7
1925-1926	1926-1927	-3.2	-4.5	- 1.3	.9	.9	0.0
1947-1948	1948-1949	7.9	-5.1	-13.0	8.6^1	3.1^1	-5.5^1
1952-1953	1953-1954	-1.3	.2	1.5	5.5	4.3	-1.2
1956-1957	1957-1958	2.8	1.4	-1.4	5.7	4.3	-1.4
1959-1960	1960-1961	.1	-.4	- .5	3.9	2.9	-1.0
1968-1969	1969-1970	3.8	3.5	.3	6.3	6.5	.2
1972-1973	1973-1975	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, 1952-1975, is the BLS series on Average Hourly Compensation in Manufacturing. For both series, see Data Appendix.

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

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[1] For 1947-1949, Economy-wide Compensation per Hour is used. The BLS series on Average Hourly Compensation in Manufacturing begins in 1950.

slowed in ten of the eleven cycles before 1930, wage change has in fact

accelerated in the last two downturns. Furthermore, the magnitudes

of deceleration before 1930 are in general far larger than the measures

for 1947-1960, 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. NBER rankings of business cycle severity

exist for 1920 to 1976. We use these rankings as a "benchmark" for a

measure covering the entire 1890-1976 period.[6] 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 to 1976, the gap

measure and the NBER severity index yield almost identical rank orderings.

In Table 2, the cycles are arranged according to the gap

criteria. 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 Phillips curve parameters. It is shown

below, however, that traditional econometric attempts to estimate

TABLE 2

WAGE AND PRICE BEHAVIOR DURING BUSINESS CYCLES :

CLASSIFIED BY CYCLICAL SEVERITY, 1890-1976

Peak-Trough	Δ in Price Inflation	Δ in Wage Inflation	Δ GAP x 100
Mild Contractions			
1893-1894	-12.9	-12.1	-7.5
1895-1897	- 4.4	4.4	-8.5
1899-1900	- .2	- 4.2	-1.7
1910-1911	-12.5	- 4.9	-8.2
1923-1924	- 6.6	- 6.7	-9.2
1926-1927	- 1.3	0.0	-3.7
1953-1954	1.5	- 2.1	-9.7
1960-1961	- .5	- 1.0	-3.9
1969-1970	.3	.2	-8.4
Moderate Contractions			
1902-1904	- 5.8	- 4.2	-11.0
1913-1914	- 3.3	- 7.3	-10.5
1948-1949	-13.0	- 5.5	-10.2
1957-1958	- 1.4	- 1.4	-11.4
Strong Contractions			
1907-1908	- 8.4	- 8.4	-21.0
1918-1919	-16.4	-14.8	-17.4
1920-1921	-56.8	-37.4	-25.9
1973-1975	.8	2.9	-15.8

Source: Wage and price data from Table 1.

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-WW II period.

The cycles have been grouped by severity, according to Δ GAP, where Δ GAP = GAP^t-GAP^p, 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	$\Delta GAP \times 100 < -15$

changes in the inflation-unemployment tradeoff may be flawed. In this section, we 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

$$(3) \quad \dot{w}_t = \beta_0 + \beta_1 \, RU_t^{-1} + \beta_2 \, y \, (L) \, \dot{p}_{t-1} + e_t$$

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). 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 $y(L)\dot{p}_{t-1}$. The somewhat arbitrary nature of the specification $\dot{p}_t^e = y(L)\dot{p}_{t-1}$ is now well-known, after the justified criticism of rational-expectations theorists.[7] However, for our purposes, the distributed lag approach may be warranted. In an economy (e.g. pre-1930) where the macroeconomic structure is not well understood, much less precisely estimated in econometric work, it may be "economically rational" (see Fiege and Pearce [4]) 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

TABLE 3

Phillips Curve Estimation, 1890-1976 (Annual Data)

	Period	β_0	β_1	β_2	$\dot{p}^e$	Post-WW I Dummy Variable	R^2	D.W.	$\hat{\rho}$
1.	1897-1929	.002 (.24)	.53 (6.4)	constrained to 1	λ=.41 (4.3)	.057 (2.2)	.71	1.13	
2.	1954-1976	.025	.087	constrained to 1	λ=.54 (5.66)		.99	1.62	
3.	1897-1929	.013 (1.9)	.40 (5.56)	.49 (5.56)	λ=-.40 (3.48)	.09 (4.1)	.79	1.19	
4.	1952-1976	.020 (3.38)	.071 (1.65)	1.19 (5.61)	λ=.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.	1952-1976	.02 (5.78)	.114 (3.53)	$\sum_1^3 \lambda_i$ =1.14			.997	1.88	-.35 (1.88)

and the structure of $y(L)\dot{p}_t$. 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. 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 we analyzed, the results for shifts in the Phillips curve hold for both RU_t and GAP_t as explanatory variables. 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, i.e. 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 $\dot{p}_t^e$, λ, is not well measured, and has the wrong sign in regression (3).

In his recent analysis, Wachter [17] reached very different conclusions regarding the change of β_1 over time. Wachter concluded that the short-run Phillips Curve has become increasingly steep. Wachter's analysis concerns the 1954-1975 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. Wachter estimates a modified form of (2):

$$(5) \quad \dot{w}_t = \beta_0 + \beta_1 \, RU_t^{-1} + \beta_2 \, y \, (L) \, \dot{P}_{t-1} + \beta_3 \, RU_t^{-1} \cdot TIME$$

Since $\dfrac{d\dot{w}_t}{dRU_t^{-1}} = (\beta_1 + \beta_3 \cdot TIME)$, 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.[8] 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:[9]

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

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 mark-ups over standard unit labor costs. Price changes approximately equal wage changes less trend productivity growth, $\dot{q}^t$. Rewriting (3) with $\dot{w}_{t-1}-\dot{q}^t=\dot{p}_{t-1}$, we have

(5) $\dot{w}=(\beta_0-\beta_2\dot{q})+\beta_1 RU^{-1}+\beta_2 y(L)\dot{w}_{t-1}+e_t$. Now, if the e_t is a serially correlated process, $y(L)\dot{w}_{t-1}$ 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 i.i.d. Note that $\hat{\rho}$ is statistically significant in both of these equations. With the auto-correlation 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 mark-ups over standard unit labor costs, lead to the following simple model:

(writing GAP_t for RU_t^{-1}):

$$(6) \quad \dot{w}_t = \beta_0 + \phi \ (GAP)_t + \dot{p}_t^e + e_t$$

$$(7) \quad \dot{p}_t^e = (1-\lambda)\dot{p}_t + \lambda\dot{p}_{t-1}^e$$

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

If trend labor productivity growth is at a constant rate $\dot{q}$, then (8) may be re-written as $\dot{p}_t = \dot{w}_t - \dot{q}$. Notice that (7) may be re-written as $\dot{p}_t^e = \frac{(1-\lambda)\dot{p}_t}{1-\lambda L}$. Using this expression with (6) and (8) we may derive

$$(9) \quad \dot{w}_t - \dot{w}_{t-1} = \Delta\dot{w}_t = \frac{(1-\lambda)\ (\beta_0 - \dot{q})}{\lambda} + \frac{\phi}{\lambda} GAP_t - \phi GAP_{t-1} + \frac{e_t}{\lambda} - e_{t-1}$$

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 $\Delta\dot{w}_t = 0$, and $GAP_t = GAP_{t-1}$. We find $GAP^{NR} = \frac{(\beta_0 - \dot{q})}{-\phi}$. The equation to be estimated becomes

$$(10) \quad \Delta\dot{w}_t = \frac{-\phi}{\lambda}(1-\lambda)GAP^{NR} + \frac{\phi}{\lambda}GAP_t - \phi GAP_{t-1} + \frac{e_t}{\lambda} - e_{t-1}$$

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

$\Delta\dot{w}$ and $\Delta\dot{p} > 0$. Thus, whenever aggregate activity is rising (i.e.,

$\text{GAP}_t - \text{GAP}_{t-1} > 0$) and employment or output in period t-1 is above the

equilibrium level, inflation should intensify ($\Delta\dot{w} > 0$). 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 ($\text{GAP}_{t-1} > \text{GAP}^{NR}$). In ten

of these years wage inflation accelerated as predicted. In nine years of

the periods 1893-1929 and 1948-1975, the economy was characterized by low

and falling levels of aggregate activity. In six years, wage inflation

showed a declining rate.[10] The accelerationist property is justified.

Equation (10) may be estimated by ordinary least squares (OLS)

or by a maximum liklihood procedure (non-linear squares). With OLS we

estimate:

$$(11) \quad \Delta\dot{w}_t = \zeta_o + \zeta_1 \text{GAP}_t + \zeta_2 \text{GAP}_{t-1} + \mu_t$$

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

$(- \dfrac{\hat{\zeta_2}}{\zeta_1}) = -$plim $(\hat{\zeta_2})$ / plim $(\hat{\zeta_1}) = \lambda$. In addition, since $\zeta_o = \dfrac{-\phi}{\lambda} (1-\lambda) \text{GAP}^{NR}$,

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 esti-

mates of the underlying parameters , (see Griliches [8], pp. 32-33). With

non-linear least squares (NLS), we may directly estimate the underlying

parameters of the model.[11] Because (12) is exactly identified, i.e., there

is a one-to-one mapping from $(\zeta_0, \zeta_1, \zeta_2)$ to $(\text{GAP}^{NR}, \phi, \lambda)$, the OLS and

NLS estimates of the underlying parameters are identical.

In Table 5, we present a summary of estimates of the model.

The results are encouraging. In all of the regressions, the co-efficients are of expected sign, and are usually statistically significant. In general, the estimates of ϕ are close to the estimates 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, $\frac{\lambda}{1-\lambda}$, has also lengthened over time. While λ is a crucial parameter for macroeconomic policy-making, as we show below, it is not precisely estimated by the equations of Table 4.

If ϕ and λ can be considered as exogenous to the policy-maker (the discussion of Section III indicates that ϕ and λ change with varying macroeconomic 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_o} in year t_o, policy makers choose $\delta \cdot GAP_{t_o}$ 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.

TABLE 4

PHILLIPS CURVE ESTIMATION, 1893-1975, EQUATION (11)

	Period	Dependent Variable	$\hat{\phi}$	$\hat{\lambda}$	$\hat{GAP}^{NR}$	Post-WW I Dummy Variable	s.e.	D.W.
1.	1894-1926	$\Delta \dot{w}_t$ (1)	.50 (5.36)	.63 (5.82)	.02 (.93)	.10 (3.42)	.049	1.92
2.	1895-1929	$\Delta \dot{w}_t$ (2)	.36 (3.57)	.53 (3.88)	.014 (.51)	.015 (.48)	.053	2.19
3.	1895-1929	$\Delta \dot{p}_t$	.31 (3.58)	.68 (3.42)	.033 (.57)	.087 (3.03)	.048	2.13
4.	1950-1975	$\Delta \dot{w}_t$ (1)	.14 (2.80)	1.31 (2.83)	.06 (.53)		.012	2.26
5.	1952-1975	$\Delta \dot{w}_t$ (2)	.038 (.53)	4.37 (.16)	.011 (.098)		.015	1.94
6.	1950-1975	$\Delta \dot{w}_t$ (3)	.13 (2.14)	.997 (2.48)	-3.03 (.06)		.014	2.47
7.	1950-1975	$\Delta \dot{p}_t$	.026 (.32)	.41 (.38)	-.10 (.51)		.018	2.08

Sources: W_t (1) is Average Hourly Earnings in Manufacturing
W_t (2) is Average Hourly Compensation in Manufacturing
W_t (3) is Average Hourly Compensation, economy-wide
P_t is GNP Deflator

For all data, see descriptions in Data Appendix

$\Delta \dot{X}_t = (\log X_t - \log X_{t-1}) - (\log X_{t-1} - \log X_{t-2})$. s.e. is standard error of the regression.

All regressions use non-linear least squares estimation.

Then it can be shown that:[12]

$$(12) \quad \dot{P} \text{(steady state)}= \dot{P}_{t_o} + \frac{\phi GAP_{t_0} \; (\delta-\lambda)}{\lambda \; (1-\delta)}$$

Thus, starting in a recession ($GAP_{t_o} < 0$), the following conditions imply a high steady-state rate of inflation: (1) a rapid recovery (low δ); long lags in expectations (high λ); 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 1974-1975 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 irrevelant 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."[13]

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 we now show in Section III.

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 in 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 cyclical 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 macroeconomic policy since World War II has probably changed the cyclical behavior of wage and price setters. Martin N. Baily [1] has recently argued that growing expectations of countercyclical macroeconomic 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 Sachs [11], and will outline the main argument here.

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 cyclically responsive than non-union wages

(cf. Lewis [9], Flanagan [5]), and the usual explanation for this

points to the use of long-term wage agreements in the union sector.

Over our 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 macroeconomic

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, Phelps [10] has succinctly

stated this view:[14]

> 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.

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.[15] Simple regressions describing
money supply growth indicate that both supply characteristics have changed
in the direction tending to reduce the Phillips curve slope.[16] In the
period 1895-1929 there is no evidence of a countercyclical response of
the money supply. For 1952-1975, the regression indicates that the
money stock is raised one percent above trend in the year following a
ten 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 1952-1975, 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 [5] recent study of union - non-union
wage differentials. Comparing the contract (union) sector with the
non-contract sector, Flanagan writes:[17]

> 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. <u>Most of the
> inertia in negotiated wages is a by-product of
> multi-year labor agreements</u>. (Emphasis added)

Second, we have shown in Sachs [11] that wages determined in the

<u>non-contract</u> 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 non-contract 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 non-contract labor market is cleared at a given

real wage, the reduced aggregate price fluctuations result is 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.[18]

And the contracts now cover a larger portion of the work force. In

the manufacturing sector, for instance, only 11.6% of production workers

were organized in 1910, while by 1973, approximately 49% of manufacturing

production employees were organized by labor unions. Economy-wide,

5.8% of the Civilian labor force belonged to unions in 1910, while

23.4% belonged in 1970.[19]

The two explanations for increasing cyclical wage rigidity, activist macroeconomic 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 we documented in Sections I and II of this paper. Given the crucial importance of the Phillips curve slope for macroeconomic policy, as suggested on p. 15, this research should soon be undertaken.

NOTES

[1] Phillip Cagan, "Changes in the Recession Behavior of Wholesale Prices in the 1920's and Post-WW II," Exploration in Economic Research, Vol. 2, No. 1 (1975), pp. 54-55.

[2] Michael Wachter, "The Changing Cyclical Responsiveness of Wage Inflation," Brookings Papers on Economic Activity, 1976:1, p. 116.

[3] With unemployment hovering above 20% in 1933, prices and wage stopped a four-year fall, and actually began to rise at significant rates. The Wholesale Price Index rose an average of 6.7% per year from 1933 to 1937 while the NIA wage measure for manufacturing workers increased an average of 5.9% per year. Wachter [17] notes that

> there is evidence that government measures to spur recovery were behind the upward movement in wages. The spurt in the early 1930's is generally attributed to the National Industrial Relations Act, and Wagner Act and the subsequent growth of unions may have been responsible for that of the late 1930's (p. 155).

Freedman and Schwartz [7] 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, notable,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.

[4] 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, we have compared Phillips curves estimated with manufacturing sector and economy-wide wages as the dependent variable, finding very little difference in cyclical responsiveness.

[5] See Cagan, loc. cit., pp. 99-100.

[6] See Annual Report, National Bureau of Economic Research, 1973. New York: National Bureau of Economic Research, Inc., 1973, p. 18, and other issues of Annual Report.

[7] See, for example, R. Lucas, "Econometric Testing of The Natural Rate Hypothesis," in O. Eckstein (ed.) The Econometrics of Price Determination (Washington: Board of Governors of the Federal Reserve System, 1972)

[8] Suppose, for example, that the curve's intercept but not slope has been increasing over time, so that

$$\dot{w}_t = \beta_0 + \lambda_1 \text{ TIME} + \beta_1 (RU^{-1})_t + \beta_2 y(L)\dot{p}_{t-1}, \quad \lambda_1 > 0$$

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 $| y(L)\dot{p}_{t-1}$, $RU_t^{-1})$, where the term reg ($\cdot$) is the multiple regression coefficient of GAP$\cdot$TIME in a regression of TIME on GAP$\cdot$TIME, $y(L)\dot{p}_{t-1}$, and RU_t^{-1}. Thus, β_3 would tend to be positive even though β_3 is in fact zero.

[9]The equation $\dot{w}_t = \beta_0 + \beta_1 RU_t^{-1} + \beta_2 y(L)\dot{p}_{t-1}$ is estimated for quarterly data. w_t is the average hourly earnings in manufacturing; RU_t is the unemployment rate for males age 25+; p_t is the non-form deflator and $y(L)$ is a 3rd degree PDL of length 16 quarter, unconstrained at both ends.

[10]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, 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.

[11]Note that u_t in (11) is equal to $e_t - e_{t-1}$, from (11).

There is no more nor less reason to believe that u_t is i.i.d. than to believe that e_t is i.i.d. The coefficient estimates from an NLS (or OLS) regression of (12) will be consistent whether or not u_t is i.i.d., though efficiency, and consistency of the estimates of the standard errors require that u_t be i.i.d.

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

$$(1.a) \quad \sum_{t=1}^{T} (\dot{p}_t - \dot{p}_{t-1}) = \sum_{t=1}^{T} (\frac{\phi}{\lambda} GAP_t) - \sum_{t=1}^{T} \phi GAP_{t-1}.$$

But $GAP_t = \delta^t GAP_{t_0}$, by assumption. Replacing this relation in equation (1.a) we find:

$$(2.a) \quad \sum_{t=1}^{T} (\dot{p}_t - \dot{p}_{t-1}) = \frac{\phi}{\lambda} GAP_{t_0} \sum_{t=1}^{T} \delta^t - \phi GAP_{t_0} \sum_{t=0}^{T-1} \delta$$

or, simplifying:

$$(3.a) \quad \dot{p}_T - \dot{p}_0 = \frac{\phi}{\lambda} GAP_{t_0} \cdot \frac{(\delta - \delta^{T+1})}{(1-\delta)} - \phi GAP_{t_0} \frac{(1-\delta T)}{1-\delta})$$

To find the steady state condition, take the limit with respect to T of (3.a), and rearrange:

$$\dot{p}_{ss} = \dot{p}_{t_0} + \phi GAP_{t_0} \frac{(\delta - \lambda)}{\lambda(1-\delta)}$$

[13]M. Wachter, loc. cit., p. 153.

[14]E. Phelps, "Commodity - Supply Shocks and Full-Employment Monetary Policy," Journal of Money, Credit, and Banking, Vol. 10, No. 2, (May, 1978), p. 209.

[15]Condition (1) is the one described by Phelps. Condition (2) results from the fact that any period's GAP_t is in part due to un-expected 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 $w_{t+1} - w_t$.

[16]The regressions relate money growth to lagged money growth and lagged output gap, in an equation similar to Barro [2]. For

$$\Delta M_t = \alpha_0 + \alpha_1 \Delta M_{t-1} + \alpha_2 \Delta M_{t-2} + \alpha_3 \Delta M_{t-3} + \alpha_4 GAP_{t-1} + u_t, \quad u_t = \rho u_{t-1} + e_t$$

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)	
1952-1975	.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 for M_2 are given in the Data Appendix.

[17]R. Flanagan, "Wage Interdependence in Unionized Labor Markets," Brookings Papers on Economic Activity, 3, 1978, p. 673

[18]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	} .15	.11
3		.57
3$^+$		

The 1948 data are from Woytinsky [19] and the 1972 data are from BLS Characteristics of Agreements Covering 1,000 Workers or More [15].

[19]Union membership in the manufacturing sector, 1910, is from Wolman [18].   Data for 1973 are found in Freeman and Medoff [6 , p. 44]. The economy-wide percentage union membership is calculated by dividing Series D952 by Series D4 and D14 in <u>Historical Statistics of the United States</u> [13].

APPENDIX

DATA SOURCES

Wage Data

1. Compensation per Hour, Manufacturing

    1890-1945: Series B72 of Long-Term Economic Growth, 1860-1965 [14].
    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 [14].

    1950-1976: Hourly compensation in Manufacturing, found in United
    States Department of Commerce, Bureau of Labor Statistics [16].

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 D769-770 of Historical Statistics of the United
    States [13], developed by Douglas.

    1950-1976: Average Hourly Earnings, Manufacturing Sector, U.S.
    Department of Commerce, Bureau of Labor Statistics, Handbook of
    Labor Statistics, 1977 (Washington: Government Printing Office,
    1977), p. 81.

Economy-wide wage behavior was studied in the current period using Series
745 in Business Conditions Digest [12]. This series, "Average Hourly
Compensation, All Employees in Private Nonform 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 [14].

    1948-1976: Series 310, Business Conditions Digest [12].

2. Wholesale Prices

    1890-1945: Series B69, Long-Term Economic Growth, 1860-1965 [14].

    1948-1976: Series 330, Business Conditions Digest [12].

(Appendix cont'd)

Industrial Production

 1890-1945: Series A15, <u>Long-Term Economic Growth, 1860-1965</u> [14].

 1948-1976: Series 47, <u>Business Conditions Digest</u> [12].

Unemployment Rate, All Civilian Workers

 1890-1929: Series B1, <u>Long-Term Economic Growth</u>, 1860-1965 [14].

 1945-1976: Series 43, <u>Business Conditions Digest</u> [12].

Money Stock M2

 1890-1929: Series X415, <u>Historical Statistics of the United States</u> [13].

 1945-1976: Series 102, <u>Business Conditions Digest</u> [12].

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