A Consistent Characterization of a Near-Century of Price Behavior

By ROBERT J. GORDON*

This paper demonstrates that the commonly used Expectational Phillips Curve (*EPC*) framework cannot explain the last eighty-seven years of aggregate price behavior in the United States. The *EPC* explanation, which in its most general form relates price change to expected inflation and the *level* of detrended output, obscures the fact that price change has been much more closely related to the contemporaneous *rate of change* of detrended output. Over the near-century of annual data studied here, a change in output has shown a remarkably consistent tendency to be associated in annual data with a simultaneous change in the price level of about one-half as much. Stated another way, nominal *GNP* changes have been divided consistently, with two-thirds taking the form of output change and the remaining one-third the form of price change. This finding applies not only over the entire 1890–1978 sample period, but also over three subperiods (1890–1929, 1929–53, and 1953–78).

The dominance of the output rate-of-change (*ROC*) explanation of price change over the "level" *EPC* explanation confirms previous findings by Allan Meltzer, myself, and others.[1] Nevertheless much recent literature on both postwar and historical price behavior has shown no awareness of the importance of the *ROC* phenomenon and has continued to specify equations based on the unadorned *EPC*.[2]

A second theme of this paper is that almost a century of price behavior can be explained with a single equation, in contrast to other historical studies that find it necessary to exclude years of depression, war, or both. While the single equation estimated here has a coefficient on the "*ROC* effect" that is extremely stable over the entire sample period, it verifies a marked shift after the Korean War in the formation of expectations regarding the price level and its rate of change. This shift reinforces the emphasis placed by Meltzer and Benjamin Klein on the contrast between the regressive expectations appropriate under a gold standard and the extrapolative expectations used to predict inflation under the postwar fiat money standard. And although this shift is consistent in overall timing with the research of Phillip Cagan and Jeffrey Sachs, its representation differs here because, while the formation of inflation expectations has shifted in the postwar years, the cyclical impact of detrended output changes has not.

*Professor of economics, Northwestern University, and research associate, National Bureau of Economic Research. I am grateful to Allan Meltzer and Jeffrey Sachs for helpful discussions, and to Jon Frye and Ross Newman for their skilled assistance.

[1]Meltzer provides a convincing demonstration of the importance of *ROC* phenomena, and the unimportance of Phillips curve variables, for a sample period that includes sixty-one of the eighty-seven years studied here. R. A. Gordon shows the importance of the change of the unemployment rate in wage equations and reviews the 1958–72 literature, including several earlier articles that included the change in unemployment. My own previous research on postwar structural price equations has always found strong effects of the rate of change of detrended output or a similar demand variable. For examples of such equations, and for evidence that the *ROC* explanation is also important for postwar wage behavior, see my 1977 article, especially pp. 269–70. I discovered the importance of the *ROC* explanation of interwar price behavior in writing a textbook case study (1978, pp. 162–65), and my article with James Wilcox provided subsequent econometric support.

[2]The recent study of historical price behavior by Jeffrey Sachs neither cites any of the papers listed in fn. 1 nor makes any mention of *ROC* variables. Edward Gramlich utilizes a so-called "mainline" model for the explanation of postwar inflation in which neither the wage nor price equations contain any *ROC* variables. Many other similar econometric models of the postwar inflation process could be cited.

I. Specifying a Reduced-Form Price Equation

This paper concentrates on results for annual price data.[3] Several recent papers take as their point of departure a standard *EPC* framework that makes the inflation rate (p_t) depend on the expected inflation rate (p_t^e) and the "gap" between actual and "natural" output (or unemployment). In the following discussion it is convenient to designate *log*s of levels of variables by uppercase letters; rates of change by lowercase letters; and the gap variable as the *log* of the ratio of actual real *GNP* to natural real *GNP* ($\hat{Q}=Q-Q^*$). Thus, the *EPC* hypothesis becomes

$$(1) \qquad p_t=\alpha_0+\alpha_1\hat{Q}_t+\alpha_2 p_t^e+\eta_t \qquad \alpha_1>0$$

where η_t is an error term. We would expect $\alpha_2=1$ if the "natural rate hypothesis" holds and if expected inflation is measured accurately, and $\alpha_0=0$ if the *log* of natural output (Q^*) is measured accurately.

We shall find, however, that (1) is too restrictive a hypothesis to allow adequate characterization of secular changes in *U.S.* price behavior. Instead, a more general approach can be developed if we start with a simple aggregate supply function that allows the difference between the actual and expected price *level* to respond positively to the output ratio ($\hat{Q}$):

$$(2) \qquad P_t=\beta\hat{Q}_t+P_t^e+\epsilon_t \qquad \beta>0$$

The positive slope of the aggregate supply curve can be explained in traditional textbook fashion as resulting from the diminishing marginal productivity and increasing supply schedules of factor inputs, including both materials and labor. It is also consistent with the strong effect of output-ratio variables on the price of inelastically supplied primary products and on oligopolistic price markups found in recent studies of postwar data.[4]

A general specification of the formation of expectations allows agents to distinguish between expected inflation (p_t^e) and shifts in the expected price level (P_t^e):

$$(3) \qquad P_t^e=p_t^e+\lambda P_{t-1}+(1-\lambda)P_{t-1}^e \qquad 0<\lambda<1$$

The expected rate of inflation in turn can be specified to depend on past values of actual and expected inflation and any other relevant information, for example, the past rates of change of nominal or real *GNP*, the money supply, wages, or unemployment.

An appealing feature of (3) is its applicability to price series with differing patterns of serial correlation. For instance, under a gold standard we might find the price level jumping up and down around a stable or slowly moving trend, and in this case the parameter λ might be small. But under the postwar fiat money standard, few increases in the price level have been reversed. Thus rational agents might set $\lambda=1$ and then apply this period's expected inflation rate (p_t^e) to last period's *actual* price level.

> If, for example, an eight percent inflation rate occurred in a particular year [under the gold standard], an inflation rate of approximately minus eight percent would likely occur a short time later.... The gold standard can be considered to have been a period of *mean reversion* in the rate of price change while the current period is one of persistence or long-term *mean revision* in the rate of price change [Klein, pp. 193–94, his emphasis].

When (3) is substituted into (2), with a bit of manipulation we can derive an equation that relates the rate of inflation to the expected rate of inflation, and to both the

[3]Results for annual wage data are briefly discussed below. Quarterly data extending back to 1900 have also been prepared for most of the variables and will be studied in a future paper.

[4]In addition to my 1977 evidence supporting a relation between the price markup and detrended output, Richard Cooper and Robert Lawrence find a significant relation between the prices of nonferrous metals, primary fibers, and raw agricultural products on the one hand, and detrended world industrial output on the other.

level and rate of change of the output ratio:

$$(4) \qquad P_t=\beta(\hat{q}_t+\lambda\hat{Q}_{t-1})+p_t^e+\mu_t$$

Note that (4) reduces to the traditional *EPC* equation (1) only if $\lambda=1$.[5]

If the rate of change of nominal *GNP* relative to natural output growth ($\hat{y}_t=y_t-q_t^*$) is exogenous, then the $\hat{q}_t$ term in (4) will be negatively correlated with the error term, given the identity:

$$(5) \qquad \hat{q}_t\equiv\hat{y}_t-p_t$$

This problem can be avoided if we substitute (5) into (4) and obtain the following expression that relates the inflation rate to "adjusted" nominal *GNP* growth, the level of the output ratio, and the rate of expected inflation:

$$(6) \quad p_t=\frac{1}{1+\beta}\left[\beta(\hat{y}_t+\lambda\hat{Q}_{t-1})+p_t^e+\mu_t\right]$$

II. Data and Specification

Published annual data series exist for the 1890–1978 period for nominal and real *GNP*, the *GNP* deflator, consumer prices, average hourly earnings, the money supply, and the unemployment rate.[6] The "natural unemployment rate" is assumed to be constant before 1955 for an unemployment concept that excludes self-employed farmers and proprietors, since the latter experience little unemployment, and "natural real *GNP*" (Q^*) is an estimate of the real *GNP* that the economy can produce when operating at its natural rate of unemployment.[7]

Four issues must be discussed before equation (6) can be estimated. The first and most important is the choice of a proxy for the expected rate of inflation(p_t^e). Edgar Feige and Douglas Pearce have emphasized that inflation expectations should be based on all available information making a marginal contribution to the prediction of inflation that is worth more than its marginal acquisition cost. Because of the shift in monetary standards over our sample period, it is important that we allow agents to shift the variables used to form expectations, and the coefficients applied to those variables.[8] We shall find, for instance, that the lagged inflation rate was very important in helping to predict the persistence of inflation observed in the post-1952 period but was of no use in predicting inflation during the gold standard era. We also allow lagged values of the rate of change of nominal income and the money supply to influence the formation of expectations. The presence of the lagged output ratio ($\hat{Q}_{t-1}$) in equation (6) introduces an identification problem, since we do not know whether a positive coefficient indicates an important influence of that ratio on expected inflation, a high value of λ, or some mixture of the two.[9] A final difficulty is that agents observe economic data at shorter frequencies than a year, so that current variables may contain information used to form expectations. It is assumed here that expectations are based entirely on last year's data, but in future research quarterly versions of these equations will be estimated.

[5]Sachs rules out any structural relation between the inflation rate and the change in the output ratio by assumption. If the price markup in his equation (8) is allowed to be a function of the level of the output ratio, then his model becomes underidentified. See also fn 15.

[6]The starting date of 1890 is chosen because it marks the beginning of the annual Kendrick *GNP* series, Rees' cost-of-living and average hourly earnings series, and the Lebergott unemployment series. A data appendix is available for interested readers. Equations have been run with consumer prices as an alternative dependent variable and with the unemployment gap replacing the output ratio, and there was no important difference from the results presented in Table 1.

[7]The methodology is described in my book, Appendix C.

[8]Thus this paper recognizes Thomas Sargent's criticism that earlier Phillips curve work did not take account of the actual process by which inflation is generated.

[9]If a short-frequency business cycle were expected, the effect of $\hat{Q}_{t-1}$ on expectations might be negative, raising the possibility that our estimates of the coefficient on $\hat{Q}_{t-1}$ might be biased toward zero. This might help to explain the small values of λ implied by the estimated equations.

The second specification issue involves the treatment of episodes of government interference in the price-setting process. I introduce dummy variables for three such episodes: the NRA; price controls in World War II; and the Nixon era. Each dummy variable is constrained to sum to 1.0 over the years in which the program had its effect and to −1.0 over subsequent years when the program was dismantled. Thus each dummy variable sums to zero over its total period of impact, and its coefficient indicates the cumulative effect of the program in question.[10] We also allow for supply shocks by treating the relative price of food and energy as exogenous during 1947–78.[11]

The third specification issue involves the treatment of World War I, for which no dummy variables are created because there were no price controls. After Britain departed from the gold standard in 1914, agents rightly expected the structure of price setting to change from the pre-1914 norm. The significance of this temporary change in structure is tested by allowing coefficients to shift during the 1915–22 interval.[12] The burst of money creation in World War I presented a much greater contrast to the preceding gold standard era than did money creation in World War II (when the outbreak of war was preceded by four years of explosive growth in the monetary base during 1938–41). Another difference between the two wars was the widespread expectation in 1919–20 that the United Kingdom and United States would attempt to return to the prewar gold price, requiring the extinction of much of the fiat money created during the war, whereas the Fed's interest rate pegging policy prevented the development of any such expectation in 1946–47. Thus it is perhaps not surprising that, although structural coefficients were allowed to shift during World War II, no significant shift could be found other than the direct impact of the price controls.

The final specification issue involves the interaction of inflation expectations and special factors. Agents were smart enough to know that the end of wars in 1918 and 1945 made lagged prices an invalid predictor of future price behavior, and they presumably were also aware of the dismantling of NRA and the end of the Nixon era price controls. To reflect the assumption of intelligent expectation formation, the lagged price-change term used as one of the expectations proxies is constructed "net" of the estimated contribution of the dummy variables and the food-energy contribution (thus requiring iterative estimation). In addition, agents are assumed to have ignored the Great Depression and wars by setting the net lagged price-change term equal to zero in 1915–22 and 1929–49. While there is no important difference between the fit of the gross and net lagged inflation variables before 1953, the introduction of the net variable cuts in half the unexplained variance in the 1953–78 subperiod.

III. The Estimated Equation for 1892-1978 and Three Subperiods

Estimates of equation (6) are shown in Table 1. The first two lines exhibit the coefficients for the first two variables in (6). In the next two lines lagged net price change and nominal *GNP* change are proxies for expected inflation. Lagged changes in the money supply (M_2) were also introduced but appear mainly to be collinear with

[10]An additional dummy variable for The Korean War price controls proved to be insignificant. The precise values of the dummy variables are chosen to provide a measure of the timing impact of each program in annual data:

NRA Dummy		World War II Dummy		Nixon Era Dummy	
1933	0.4	1943	0.5	1972	0.5
1934	0.6	1944	0.4	1973	0.5
1935	−0.4	1945	0.1	1974	−0.3
1936	−0.6	1946	−0.6	1975	−0.7
		1947	−0.4		

[11]The "food-energy" variable in Table 1 is the difference for 1947–78 between the annual rates of change of the personal consumption deflator and the deflator net of expenditures on food and energy.

[12]The importance for expectation formation of special events, such as wars and postwar-adjustment periods, is stressed in my 1973 article.

TABLE 1—ESTIMATED EQUATIONS FOR THE ANNUAL PERCENTAGE CHANGE OF THE *GNP* DEFLATOR
(t-Ratios in Parentheses)

	1892–1978 (1)	1892–1929 (2)	1929–53 (3)	1953–78 (4)
Adjusted Nominal *GNP* Change ($\hat{y}_t$)				
a. Entire Period	.316	.287	.348	.341
	(8.83)	(3.34)	(9.65)	(8.47)
b. Extra effect, 1915–22	.306	.358	–	–
	(5.13)	(3.48)		
Lagged Output Ratio ($\hat{Q}_{t-1}$)				
a. Entire Period	.044	.176	.073	.130
	(1.86)	(1.63)	(3.61)	(3.57)
b. Extra effect, 1953–78	.090	–	–	–
	(0.60)			
Lagged "Net" Price Change (p^N_{t-1})				
a. Entire Period	−.225	−.041	−.731	.722
	(−1.49)	(−0.17)	(−2.96)	(10.09)
b. Extra effect, 1953–78	.836	–	–	–
	(2.80)			
Lagged Adj. Nom. *GNP* Change ($\hat{y}_{t-1}$)				
a. Entire Period	.179	.059	.147	–
	(3.99)	(0.57)	(3.21)	
b. Extra effect, 1915–22	.120	.209	–	–
	(1.86)	(1.82)		
c. Extra effect, 1953–78	−.305	–	–	–
	(−1.31)			
Special Factors				
a. NRA dummy, 1933–36	8.94	–	8.45	–
	(3.90)		(5.00)	
b. World War II dummy, 1943–47	−17.85	–	−17.39	–
	(−7.62)		(−10.54)	
c. Nixon Era dummy, 1972–75	−4.77	–	–	−4.70
	(−2.35)			(−9.88)
d. Relative Price of Food and Energy	.985	–	1.222	.493
	(2.17)		(2.58)	(3.56)
R^2/Standard Error	.877/2.10	.852/2.74	.961/1.41	.964/0.49
Durbin-Watson statistic	1.89	2.10	1.50	1.72

lagged nominal *GNP*.[13] The "special factor" variables are listed last. The four columns of the table display the results of estimation for the entire sample period and three subperiods.

The remarkable stability across subperiods of the coefficients on $\hat{y}_t$ is evident, as is the significantly greater response of prices to $\hat{y}_t$ during World War I. The effect of the Phillips curve variable, the lagged output ratio, is surprisingly small—real *GNP* slack of 5 percent (an output ratio of .95) slows inflation by only two-thirds of a percentage point per year in the postwar subperiod.

The shift in the role of lagged price change from regressive to extrapolative expectations stands out, both in the shift from negative coefficients to a positive coefficient in the last subperiod, and to the significance of the "extra 1953–78 effect" in the full sample period. This shift in structure was introduced in two alternative ways to compare Cagan's hypothesis that the recession flexibility of prices has gradually diminished during postwar recessions between 1949 and 1970, and an alternative hypothesis that the new mode of expectation formation

[13]Versions with lagged money perform better in the first subperiod, but substantially worse in 1929–53, reflecting the looseness of the money-*GNP* relationship during the Great Depression emphasized in my article with Wilcox.

TABLE 2—COMPARISON OF STANDARD ERRORS

	1892–1978	1892–1929	1929–53	1953–78
Standard Errors from:				
Table 1	2.10	2.74	1.41	0.49
Phillips Curve Alternative	3.83	4.70	4.48	0.79
Standard Deviation of Price Change	5.52	6.52	6.02	2.33

suddenly began in 1953. The Cagan hypothesis is tested in both columns (1) and (4) by multiplying the applicable lagged price-change variable by the time trend that moves smoothly from zero to unity between 1953 and 1970 and remains at unity thereafter. The Cagan variable does significantly worse in the postwar subperiod and cannot explain why inflation was so low during 1961–65 in the face of rapid nominal *GNP* growth.

How well do the equations in Table 1 fit as compared to the simple *EPC* alternative? Table 2 is a comparison of the standard errors of the equations in Table 1 with an *EPC* specification of Sachs which includes only the current output ratio and four lagged values of the dependent variable.[14]

Results similar to those in Table 1 have been obtained for the same specification applied to wage-change data. The similarity of the price and wage results suggests that the increased inertia observed in the postwar period characterizes wages and prices together rather than any shift in the cyclical behavior of the real wage. The annual change in the real wage responds negatively to the lagged output ratio, and positively to $\hat{y}_{t-1}$ (before 1953), to the NRA, and to both the World War II and Nixon era dummy variables.

IV. Implications

The results in Table 1 establish that the elasticity of price change to nominal *GNP* change has been approximately one-third for almost a century, and that the serial correlation in the price-change variable has shifted from negative to positive at some point in the early 1950's.[15] The inertia in the price-change process in the postwar period tends to dissuade policymakers from halting inflation, because a sluggish response of price change to restrictive demand policy creates high unemployment and political pressure to abandon the tight policy. But the extremely simple equation displayed in column (4) of Table 1 for the postwar years suggests a much greater payoff to restrictive demand policy than has recently been believed. An artificial (and implausible) experiment which drops adjusted nominal *GNP* growth from 6 to 0 percent causes inflation to slow down 1.8 percentage points in the first year, another 1.8 points in the second year, and 1.7 points in the third year, for a total response of 5.3 points after only three years.[16]

[14]To emphasize the contribution of the $\hat{y}$ variables in Table 1, the four "special factor" variables are introduced into the Sachs specification in addition to his dummy variable for World War I.

[15]Two questions of interpretation can be raised about the results in Table 1. First, the mere fact that the rate of price change depends on the change in $\hat{Q}$ does not by itself rule out a traditional Phillips curve interpretation, since Sachs has shown in his equation (10) that it is possible to combine my equation (1) above with an adaptive expectations specification of the determination of P_t^e and derive a reduced-form relationship between p_t, p_{t-1}, and $\hat{q}_t$. However this approach requires that the coefficient on p_{t-1} be constrained to equal 1.0, a constraint that seems quite inconsistent with the results in Table 1 for the pre-1953 period. Also, Sachs' estimates of his equation (10) for 1950–75 have a standard error three times higher than my postwar equation in Table 1. The second issue of interpretation concerns the low estimate of $\lambda = 0.4$ for 1953–78 implied by Table 1; this anomaly suggests to me that (2) and (3) may be too restrictive a structural specification and that the results in Table 1 may better be viewed as supporting a general structural dependence of price change on both the level and rate of change of output, as in (4).

[16]Of course the output ratio falls rapidly as well from 1.00 to .929 at the end of the third year. Then a subsequent policy in the fourth through sixth years of 3.0 percent adjusted nominal *GNP* growth will leave the economy with an inflation rate of only 1.3 percent and an output ratio of .993.

The change in the structure of expectation formation in the postwar period also reminds us that the conclusions of many econometric studies may be sensitive to extensions of sample period.[17] And it seems quite consistent with a change in attitude in the first postwar decade toward recognition of a fundamental change in the stabilizing role of government policy (initiatives based more on the automatic stabilizers and new institutions like FDIC than on countercyclical policy). The shift also emphasizes the crucial role of three-year staggered-wage contracts, a unique American institution that dates back to the first postwar decade and that introduces positive serial correlation in the wage-change data which in turn leads rational economic agents to expect positive serial correlation in the price-change data.

Some proponents of the classical equilibrium approach to macroeconomics, particularly Robert Barro, protest that, because these wage-setting institutions impose a high cost on some workers who experience employment fluctuations, they must not exist. Barro's position ignores the fact that rational firms and unions have chosen this bargaining pattern to minimize the real private costs of negotiations and strikes. The alternative classical equilibrium explanation of business cycles, that output responds positively to price "surprises," seems an implausible description of the last two decades in terms of the price equation developed in this paper, since the prolonged output boom of 1965–69 followed five straight years (1963–67) when price change was lower than the postwar equation can explain, while the "great recession" of 1974–75 occurred after six straight years (1970–75) when price change was *higher* than the fitted value.[18]

[17]The findings of Feige and Pearce that money contributes nothing to the explanation of prices, when the influence of lagged prices is held constant, is likely to be highly dependent on their 1953–71 sample period.

[18]The cumulative price error of -2.01 percentage points in 1963–67 can be contrasted with a swing in the output ratio ($\hat{Q}$) of $+8.8$ percentage points in 1961–66; the cumulative price error of $+2.6$ percentage points in 1970–75 can be contrasted with a swing in the output ratio of -7.8 percentage points in 1973–75.

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