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Anticipated Inflation and Unanticipated Price Change: A Test of the Price-Specie Flow Theory and the Phillips Curve

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by

Allan H. Meltzer

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Anticipated Inflation and Unanticipated Price Change

A Test of the Price-Specie Flow Theory And the Phillips Curve

The Phillips curve is widely accepted as the maintained theory of inflation. In the standard version of the theory current inflation depends on some measure of anticipated inflation and on the deviation of current output from full-employment output. Most recent studies of inflation report the continuing search for variables that increase the accuracy with which the theory predicts or forecasts. Recent surveys by Laidler and Parkin [15] and by Gordon [11] summarize these developments. An entirely different direction has been taken by Lucas [17, 19, 20] and Phelps [25]. These authors seek to provide a firm micro-foundation for the relation.

The Phillips curve differs from earlier explanations of price fluctuations. Hume, Thornton, and other early exponents of the price-specie flow theory relate price levels to output, so that the short-run rate of price change depends on the rate of change of output and not on the current or past level of output. Producers respond to changes in demand by moving along positively sloped supply curves. Aggregate supply is the appropriately weighted sum of individual producer's supplies. Prices

*Much of the work appearing here has developed from the discussions that I have had for many years with Karl Brunner and from our joint work. Brunner's long-time interest in the problems addressed is well known. I am pleased that this attempt at explanation appears as an essay in his honor. As teacher, collaborator, and friend, he stimulated my interest in the problems addressed and in the importance of economic analysis and evidence for correct conclusions. I am indebted to Timothy McGuire for helpful suggestions and to Walter Dolde, William Dewald, Helmuth Frisch, John Bryant, Robert Hodrick, and Claudio Haddad for criticisms of previous drafts and to the participants in the 1976 Konstanz seminar for helpful comments.

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and output respond positively to changes in demand. I know of no recent effort to
develop the Hume-Thornton analysis as an alternative to the Phillips curve or to test
the Phillips curve by comparison with the alternative theory.¹

There are, moreover, reasons for skepticism about much of the evidence used to
support Phillips curves. First, economic theory implies that agents respond differ-
ently to one-time price changes and maintained rates of price change. This distinc-
tion is ignored in every empirical study of inflation that uses past rates of price
change to measure anticipated inflation. Most studies [11, 15, 24] include one-
time changes in the price level in measures of anticipated inflation contrary to
economic theory.

Second, much of the evidence is drawn from a brief period with a particular type
of international monetary arrangement. The formation of price anticipations de-
dpends on the prevalent type of monetary arrangements. Under a gold standard, a
rise in the domestic price level relative to prices abroad implies that domestic prices
must fall in the future. Under the dollar standard, as Klein [14] has suggested, an
increase in the current rate of inflation carries no implication of later deflation.
Little evidence has been produced to show that Phillips curves are capable of ex-
planing price changes in the interwar period or under the gold standard.

There has been much discussion of Friedman’s proposition that inflation is always
a monetary phenomenon [8]. Standard theory [23] implies that a one-time change
in tastes, the degree of monopoly, or other real variables changes the price level.
Empirical observation suggests that, generally, real changes do not occur at a steady
rate but occur discretely and, therefore, affect the price level and not inflation.
Hence, Friedman’s proposition cannot be falsified by showing that some changes in
the price level result from nonmonetary causes. To reject the proposition, we re-
quiere a theory that distinguishes between once-and-for-all price changes and main-
tained rates of price change. The model developed here makes the distinction,
thereby permitting a test of Friedman’s proposition.²

The term “inflation,” as used here, means the rate of price change maintained
for a period of time (to be defined more precisely below). The “rate of price
change” includes inflation and all changes in the price level.³

In the following sections, I develop a model relating output, inflation, and rates
of price change to monetary and fiscal variables and to anticipations. I estimate
anticipated inflation and output using a procedure similar to McGuire’s [22]. Then
I use the estimates to separate the effects of anticipated inflation on the current
rate of price change from the effects of random and systematic changes in the price
level.

¹Lucas [19, 20] develops an equilibrium model in which the aggregate supply curve relates
output to the rate of price change.
²Helmut Frisch points out that when rates of change dominate and the effect of levels is
small, Friedman’s adjustment equation in [9] is closer to what I have called the price-specie
flow model than to the Phillips curve.
³The use of “inflation” to refer to current rates of price change and maintained inflation
creates a problem analogous to the use of “growth” to refer to the rate of change of output
during a finite interval that includes a recovery or a recession. Some may prefer the terms
short- and long-term inflation, current and maintained inflation, or even permanent and transi-
tory inflation to my terminology.
Phillips curves attribute inflation to excess demand and excess demand to government policies [5, 11, 15]. Evidence of the effect of policies is rarely presented. In contrast, the model developed here provides estimates of the responses to government policies and tests some central propositions about the effects of the growth of money and other variables on inflation and output.

A THEORY OF INCOME, INFLATION, AND PRICES

The economy I consider has many of the features of classical or neoclassical theory. The steady-state path of aggregate, anticipated income is determined by real resources. Wealth consists of tangible real assets, government debt, and money balances. The steady-state growth path of the economy is given by equation (1) obtained from the quantity equation.

\[ \mu = \beta^a + g, \]  

where \( \mu \) is the maintained rate of monetary expansion, \( \beta^a \) is the fully anticipated rate of inflation, and \( g \) is the rate of change of fully anticipated output or real income.

The economy does not remain on the steady-state path, so current receipts and income differ. The term income refers to the realizations along the path; “receipts” refers to the actual or anticipated current value of aggregate output available for spending. Spending is a rate of purchase of durables and nondurables and depends on receipts; consumption is the rate of use and depends on income. When consumers’ receipts are less than their income, consumers reduce spending, maintain consumption, reduce inventories of assets, and lower replacement relative to depreciation. Friedman [7] gave the name “transitory income” to the difference between income and current receipts and provided an explanation of the relation of consumption to income and receipts, but he did not investigate differences between consumption and spending or indicate how receipts are determined. Fluctuations in receipts relative to income constitute most of the movements known as the business cycle.

I assume that each individual acts as if his anticipated current receipts depend on his total wealth and the way in which society uses available resources. Anticipated aggregate receipts \( y^a \) is obtained by summing individual anticipations \( y^a/L \) shown in equation (2).

\[ \frac{y^a}{L} = H \left[ \left( \frac{K}{L} \right)^\alpha \left( \frac{L}{N} \right)^\beta (L_g)^\gamma \left( \frac{S}{\rho} \right)^\delta e^{k B p} \right], \]  

\[ \alpha, \gamma, k > 0, \beta < 0. \]

The \( H \) function is assumed to be homogeneous of degree one in population \( N \), capital, and labor force. Anticipated receipts per worker depend on capital per
worker $K/L$, the proportion of the population in the labor force $L/N$, the absorption of labor by government $L_g$, and on real government debt $S/p$, and base money $B/p$ held by the public. Per capita receipts vary directly with capital per worker and inversely with participation in the labor force. Absorption of labor by government reduces the supply of labor to the private sector. Privately produced output falls, but government services increase. Since there is no force equating the marginal social product of government service to the wage rate paid by government, real wages and anticipated receipts change when $L_g$ changes [6].

The financing of past government budgets and balances of payments determines the current stocks of financial assets $S$ and $B$. Current values of financial stocks are known, but future increments are unknown and subject to variations that are a principal cause of fluctuations in output and prices [3, 4, 8, 21]. I assume that fluctuations in policy are so erratic that rational individuals forecast neither the timing nor the magnitude of current changes in $B$ and $S$.\(^4\) Once the changes occur, however, agents adjust.

Equation (2) permits agents to respond to changes in the composition of wealth. By issuing or withdrawing base money and debt, the government affects anticipated output, changing relative prices and the composition of spending [3, 4, 28]. Budget deficits financed by issuing debt increase wealth and raise interest rates. As in [3], I have assumed that the effect of $S/p$ on $y$ or $y^a$ is positive. Increases in the base raise wealth and lower interest rates. If prices do not fully adjust, real base money balances and anticipated real receipts (or output) rise and fall together.

Real base money balances change, also, when there are technological changes in the payments system. Improvements in payments technology permit agents to re-allocate effort from making payments to both production and leisure, so anticipated receipts (and output) rise. If the change in payment arrangements increases the demand for \textit{nominal} base money, real base money balances and real anticipated receipts (output) are positively related.\(^5\)

The value of aggregate current receipts (output) is a random variable that fluctuates around anticipated receipts.

\[ y_t = y^a_t u_{1,t}. \] (3)

Equation (3) recognizes two types of disturbances. First, differences between $y^a$ and \textit{income} describe the position of the economy in the business cycle. Second,\(^4\)To state the point in a way that is more consistent with recent discussions of rational expectations, individuals may hold anticipations about long-run tax rates and the size of government, but the costs of predicting the \textit{timing} of policy actions are high relative to the costs of monitoring current operations. I assume that, as the evidence in Hamburger and Platt suggests [12], individuals monitor policy actions, and every policy action is "known" up to a random component when it occurs. The assumptions about the lag structure of equation (2) are introduced when estimation is discussed below.

\(^5\)This interpretation of productive monetary arrangements is developed in Brunner and Meltzer [2]. The contribution of money balances is not as in Sinai and Stokes [27] a "direct" contribution of money balances to output. Some notable changes in exchange arrangements are the introduction of the Federal Reserve System and the breakdown of the international gold standard in the thirties.
agents make errors using equations (2) and (3) to forecast anticipated receipts. The forecast error \( u_{1,t} \) in equation (3) includes real shocks and unanticipated changes in government policies.

The rate of change of anticipated receipts fluctuates around the economy's growth path. When the rate of change of anticipated receipts is above or below the growth rate of income, the rate of change of planned spending is above or below the growth rate of steady-state consumption and investment. Equation (4) describes the relation between the anticipated rate of change of aggregate spending in nominal terms \( \mu + \hat{p}^a \) and the current anticipated rate of change of receipts \( y^a + p^a \).

The anticipated rate of change of velocity \( \hat{V}^a \) depends on changes in the anticipated rate of price change, \( \hat{p} = d \hat{p}^a/dp^a \), and on the rate of change of anticipated receipts \( y^a \). When \( \hat{p}^a \) is constant (\( \hat{p} = 0 \)) and \( y^a = g \), velocity is constant and agents expect the economy to move along the steady-state path shown in equation (1).

\[
\mu + \hat{V}^a (\hat{p}, y^a) = y^a + p^a. 
\] (4)

The actual rate of price change \( \ddot{p} \) is not identical to \( \hat{p}^a \), and current spending is not identical to planned spending. Current private spending is \( MV \), and current receipts is the sum of the receipts of individual agents, \( py = \sum p_i y_i \). The growth of actual private spending and receipts in any year is obtained by taking logarithms of the quantity equation \( MV = py \) and differentiating to obtain relative rates of change. Fluctuations in government services are measured by the growth rate of public employment \( \hat{L}_g \), so \( \hat{y} - \hat{L}_g \) is the rate of change of private output.

\[
\hat{M} + \hat{V} = \ddot{p} + \hat{y} - \hat{L}_g, 
\] (5)

where \( \hat{M} \) and \( \hat{V} \) are the relative rates of change of money and actual velocity and \( \ddot{p} \) and \( \hat{y} \) are relative rates of change of prices and total current real receipts. By subtracting equation (5) from equation (4) and rearranging terms, we obtain an equation for the difference between the actual and anticipated rate of price change.

\[
\ddot{p} - \hat{p}^a = \hat{y} - \hat{M} - \mu + \hat{L}_g + \hat{V} - \hat{V}^a. 
\]

To test Friedman's proposition [8] that inflation is a "monetary phenomenon," assume that \( \hat{p}^a = \mu - g \) and that \( g \) is constant. Observed rates of price change differ from anticipated inflation whenever there are adjustments in velocity or errors in forecasting current receipts. Adjustments of velocity and errors are one-time events that affect the price level but not the maintained rate of inflation.

\[
\ddot{p} = \hat{M} + \hat{V} - \hat{V}^a - \hat{y} + \hat{L}_g + y^a - g. 
\] (6)

6 The circumflex symbol denotes the relative rate of change throughout, and a superscript "a" denotes an anticipated or planned value.
7 At first glance, it appears that I have adjusted \( \hat{y} \) but not \( y^a \) for government absorption of labor \( L_g \). The effect of \( L_g \) on \( y^a \) is given by equation (2), which is used to compute \( y^a \).
To complete the hypothesis, we require information about the response of velocity. The demand function for money provides the underlying analysis. As in [3], the demand for money balances depends on total wealth, the market rate of interest, and the prices of assets and output. The market value of wealth is the sum of base money, government debt, and real capital at market prices. In a full equilibrium, assets sell at replacement cost and the output price level differs from the anticipated level by anticipated price change. Fluctuations in the economy induce changes in the prices of assets and output. I assume that wealth owners use the anticipated price level $p^a$ as an index of the anticipated cost of withdrawing output for use as capital so that $c_0 p^a$ is a measure of the replacement cost of assets. Further, to avoid later problems of measurement, I use nominal income as a measure of the combined effect of nominal human wealth and nominal real capital. With these adjustments, the demand function for money is:

$$M = \lambda(r + \hat{p}^a, p, c_0 p^a, yp, S, B),$$

$$\lambda_1, \lambda_3 < 0, \quad \lambda_2, \lambda_4, \lambda_5, \lambda_6 > 0.$$ 

The demand function is homogeneous of first degree in prices and the value of financial assets. For velocity and current $y$ to be positively related, the income elasticity of the demand for money must be less than unity. I have left the sign of $y$ open. Velocity, the ratio of real income to real balances, is

$$V = V\left(r + \hat{p}^a, c_0 \frac{p^a}{p}, \frac{S}{p}, \frac{B}{p}\right),$$

$$V_1, V_2 > 0, \quad V_4, V_5 < 0.$$ 

Differentiating (7) then multiplying to form elasticities makes $\hat{V}$, the relative rate of change of current velocity, depend on the relative rates of change of its determinants. Elasticities are denoted $e$ and, as before, relative rates of change are shown by a circumflex. $\hat{\pi}$ is the relative rate of price acceleration.

$$\hat{V} = e(V, r)\hat{\pi} + e(V, \hat{p}^a)\hat{\pi} + e(V, p^a)\hat{p} + e(V, S)\hat{S} + e(V, B)\hat{B} - e(V, p)\hat{p} + e(V, y)\hat{y}.$$ 

The real rate of interest is neither constant nor given in the determination of $\hat{V}$. The real rate that governs portfolio choice and intertemporal resource allocation in any year is the product of an expected return to capital per unit of capital $n$ and the ratio of the price level of current output to the price level of existing assets [3]. As before, the anticipated price level $p^a$ is an index of the anticipated cost of using a unit of output to replace or increase capital and is assumed to be proportional $(1/c_0)$ to the replacement cost of capital. The real rate of interest is, then,
where \( n = n(y - \gamma^a, B/p, S/p, L_g, \gamma^a) \), \((n_1, n_3 > 0, n_2, n_4, n_5 < 0)\).

The expected return to capital \( n \) depends on the capital stock, through the effect on \( \gamma^a \), on the real value of financial assets, and on the amount of labor absorbed by government. The current return to capital rises when agents receive information that they have underestimated the current expansion \((y < \gamma^a)\) and \( n \) falls if \( y > \gamma^a \). Absorption of labor by government raises the marginal product of labor in private production and lowers the anticipated return to capital.

Differentiating \( r \) and multiplying throughout to express the results as elasticities and relative rates of change yields equation (8).

\[
\dot{r} = [1 - e(n, p)] \dot{\beta} - \dot{\beta}^a + e(n, \gamma^a) \dot{\gamma}^a + e(n, L_g) \dot{L}_g + e(n, B) \dot{B} + e(n, S) \dot{S}.
\]  

(8)

By replacing \( r \) with equation (8), rewriting \( \dot{V}_a(\hat{\gamma}, \hat{\gamma}^a) \) from (4) in terms of elasticities and relative rates of change, and substituting in equation (6), we obtain a solution for \( \beta \).

\[
\dot{\beta} = w_0 + w_1 \beta^a + w_2 \dot{B} + w_3 \dot{S} + w_4 \dot{\gamma} + w_5 \dot{L}_g + w_6 \dot{\gamma}^a + w_7 \dot{S}^a + v_2,
\]  

(9)

The current rate of monetary expansion is measured by \( \dot{B} \), the growth rate of the monetary base. The responses to \( \dot{S}, \dot{\gamma}, \) and \( \dot{\gamma}^a \) are ambiguous. The derivation of the signs is shown in appendix 2.

ESTIMATES OF ANTICIPATED INFLATION AND REAL RECEIPTS

To test the theory of the rate of price change developed in the previous section, I require estimates of the anticipated rate of inflation and the rate of change of current real receipts. In this section, the anticipated values are estimated from past data and propositions about the formation of anticipations are tested. In later sections, I use the estimates developed in this section to test propositions about monetary and other sources of price changes.

**Anticipated Receipts, \( \gamma^a \)**

Equations (2) and (3) form a hypothesis about the formation of anticipated current receipts and the relation of anticipated to observed receipts (measured real output). Three problems arise in implementing the hypothesis. First, consistent data for the private capital stock are not available for the entire century. I combined two available series on the stock of capital to form a not entirely consistent
set of data for the relevant years. I assume that anticipated receipts in year $t$ depend only on information available at the start of the year. Agents have more information than the equation permits, but some evidence suggests [12] the net benefit of monitoring current policy actions is high relative to the benefits of predicting the timing of events. Third, I have found no way to separate the effect of lifetime income on current anticipated receipts from the effects of current receipts and current activity. The responses to $K, L, Lg$, etc., combine the response to long-term growth with the response to recovery and recession. This problem is of particular importance because the years 1929–40 are a significant part of the sample period.

Using gross private domestic product as the measure of receipts, least-squares estimates for the period 1900–74, omitting the years of price and interest rate controls, 1941–52, suggest that agents estimated aggregate receipts according to

$$\frac{y_t}{L_{t-1}} = e^{-0.041} \left( \frac{K}{L} \right)^{0.41} \left( \frac{L}{N} \right)^{1.40} \left( \frac{L_g}{N} \right)^{0.6} \left( \frac{B}{P} \right)^{0.36} N_t^{0.25}.$$ 

The point estimates imply that as population grows, aggregate anticipated receipts rise relative to labor force. Anticipated receipts increase with capital per worker and decline with increased labor force participation.

**Anticipated Rate of Inflation**

Anticipations of inflation depend on the prevailing monetary standard. Under a pure gold standard, maintained growth or contraction of the monetary gold stock brings inflation or deflation. Rational agents in the gold standard countries base anticipations of world inflation on the maintained rate of change of the world gold stock. Maintained change in domestic money at rates inconsistent with the growth

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8 A complete list of sources and procedures is given in appendix 1. Note that debt is the outstanding stock of government debt minus net foreign debt and debt owned by the Federal Reserve.

9 The coefficient of $S/p$ is close to zero (see below) and is omitted in the text. The Durbin-Watson statistic shows substantial serial correlation, but I made no effort to adjust the estimates. Little is known about aggregate anticipated output. It is not unreasonable for the aggregation of individual forecasts to yield forecasts that remain above or below actual output for several years in succession. The least-squares estimates are shown with $t$-statistics in parentheses, D-W the Durbin-Watson statistic, and $R^2$ adjusted for degrees of freedom. A dummy variable was used for World War I (1917–19), and a second dummy was used to adjust for the break in the capital stock series (1925) and the break in the data series (1953). The regression equation is:

$$\ln y_t = -9.64 + 0.049 \ln K_{t-1} - 1.802 \ln L_{t-1} + 0.090 \ln L_{g_{t-1}}$$

$$+ 1.300 \left( \frac{P}{P} \right)_{t-1} - 0.004 \ln \left( \frac{S}{P} \right)_{t-1} + 2.646 \ln N_t$$

$$\ln y_t = -9.64 + 0.049 \ln K_{t-1} - 1.802 \ln L_{t-1} + 0.090 \ln L_{g_{t-1}}$$

$$+ 1.300 \left( \frac{P}{P} \right)_{t-1} - 0.004 \ln \left( \frac{S}{P} \right)_{t-1} + 2.646 \ln N_t$$

The equation was estimated with none of the variables in per capita terms. If the lagged values of $K$ and $L$ are deflated by labor force and population, an equiproportionate increase in $K, L$, and $N$ raises $y$ more than proportionally.
of the world gold stock generates anticipations of domestic inflation and devaluation or deflation and revaluation. Persistent difference between domestic and foreign price levels requires the central bank to pay out or absorb gold, adjust the stock of money, and devalue or revalue currency in terms of gold.

The international gold standard ended after Britain gave up the standard in 1931. The United States devalued in 1934 and ended the formal link between gold and the dollar in 1971. Following World War II, dollars became the principal component of international base money.

Under the dollar standard, maintained expansion of the U.S. money stock did not set off a process that reduced the growth rate of money. Most foreign central banks did not insist on the convertibility of dollars into gold and did not revalue; instead, they purchased dollar securities, expanded stocks of money, and permitted prices to rise. When after 1970 foreign governments chose to separate domestic inflation from U.S. inflation, the dollar standard ended, and an era of fluctuating exchange rates began.

If rational agents use information about the monetary standard when estimating the anticipated rate of inflation, changes in the stock of money should not have the same effect on maintained inflation during 1901-31 as during 1954-71. The years 1932 to 1940 are a mixture that I have treated separately in my estimates and in subsequent tests. I have included 1971-74 with the years of the dollar standard.

Equation (10) is a restatement of equation (1); \(g\) is constant and \(\mu\), the fully anticipated rate of monetary expansion, is defined as the weighted sum of recent and "maintained" monetary growth. A three-year, unweighted, moving average of rates of monetary change, lagged one year, is used to measure "maintained" monetary growth. The mean lag of two years does not differ markedly from some recent estimates [21]. The anticipated rate of inflation and the anticipated one-year rate of price change are identical.\(^{10}\)

\[
\hat{\rho}_t = a_0 + a_1 \hat{M}_{t-1} + a_2 \bar{M}_{t-1} + a_3 D + v_3, \tag{10}
\]

where \(\hat{\rho}_t\) is the actual rate of price change, \(\hat{M}_{t-1}\) is the growth of money in the previous year, \(\bar{M}_{t-1}\) is the average growth rate of money in the three years ending in \(t - 1\), \(D\) is a dummy variable, and \(v_3\) is the difference between anticipated and actual rates of price change. Table 1 shows least squares estimates of equation (10).

The regressions suggest that, if equation (10) is a correct representation of agents' behavior, a considerable part of the observed rate of price change is unanticipated. Agents did less well, on average, anticipating the rate of price change under the gold standard, 1900-31, than under the dollar standard. One reason is that the variance of the rate of price change was greater (0.14) in 1901-31 than in 1954-74 (0.08). A second, related, reason is that monetary growth has two effects on \(\hat{\rho}\) under the

\(^{10}\)This is very restrictive. Agents may anticipate once-and-for-all price changes, or distinguish such changes from the rate of inflation; or they may form a term structure of anticipated inflation instead of a mean rate. Silveira [26] has shown that the length of the lag depends on the rate of monetary expansion. All such problems are neglected. In passing, I note that the response of \(\hat{\rho}\) to \(\hat{M}_{t-1}\) is 0.62 for 1901-31 and 0.47 for 1901-40.
gold standard. The rate of price change is expected to respond first positively, then negatively to monetary growth. The timing of the anticipated reversal is not fixed and uniform but is uncertain.

The estimates in Table 1 show that deviations from the maintained average rate of change—accelerations and decelerations of money in the recent past—have much greater effect on $\hat{p}_a$ under the gold standard than under the dollar standard. The estimates suggest that, under the dollar standard, the rate of inflation anticipated at the start of the year is approximately the maintained average rate of monetary expansion plus a constant that is considerably smaller than $\beta$. Accelerations and decelerations have no independent effect on anticipations. Since anticipations of inflation formed and decayed more slowly under the dollar standard, sudden changes in monetary policy—stop and go policies—had their principal effect on inflation by changing the maintained rate of monetary expansion.

The three sets of estimates for equation (10) provide three interpretations of $\hat{p}_a$. I used the 1901-31 and 1954-74 regressions as the measure of $\hat{p}_a$ for those years and used the 1901-40 regression for the years 1932-40.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>1901-31</th>
<th>1901-40</th>
<th>1954-74</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{M}_{t-1}$</td>
<td>0.83</td>
<td>0.54</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(3.19)</td>
<td>(2.97)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>$\hat{M}_{t-1}$</td>
<td>-0.45</td>
<td>-0.17</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>(1.18)</td>
<td>(0.65)</td>
<td>(6.08)</td>
</tr>
<tr>
<td>Dummy for avg.</td>
<td>0.02</td>
<td>0.03</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.79)</td>
<td>(1.00)</td>
<td>(0.36)</td>
</tr>
<tr>
<td>Dummy for gold revaluation</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.56)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.001</td>
<td>-0.01</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.67)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.26/2.08</td>
<td>0.23/1.79</td>
<td>0.64/1.02</td>
</tr>
</tbody>
</table>

Note: A bar over the variable indicates a three-year moving average. t-statistics are shown in parentheses. The dummy for avg. is 1 in 1917-22 and in 1954-56 to allow for any effect of World War I and the Korean War; the dummy for revaluation is in 1934 to allow for revaluation at the end of 1933.

The current rate of price change fluctuates around the anticipated rate of inflation whenever there are random or systematic changes in the price level. If the price level does not respond instantly, the measured rate of price change during any finite interval includes the anticipated rate of inflation, unanticipated inflation, and any once-and-for-all adjustment that occurs during the interval. The estimates of the rate of inflation anticipated at the start of the year $\hat{p}_a$ permit a test of the effect of anticipated inflation and other variables on the current rate of price change.

In this section, I estimate parameters of equation (9) to test the proposition that inflation is principally a monetary phenomenon. By construction, the anticipated
rate of inflation at the start of the year \( \hat{p}_a \), given by equation (10), measures the effect of past monetary expansion. The growth rate of the monetary base is a measure of the current rate of monetary expansion. The current rate of growth of the base affects the current rate of price change and by changing the growth rate of money changes the anticipated rate of inflation in subsequent periods.

Variables other than the growth rate of the base and \( \hat{p}_a \) affect the current rate of price change but, by assumption, they can affect the anticipated rate of inflation only by changing the rate of monetary expansion. Effects of wealth, income, rates of interest, and other variables on the money stock are small relative to the effect of the base [1]. The potentially more powerful effect of some of these variables is on the rate of price change, as shown in equation (9).

Table 2 shows estimates of two forms of equation (9) for each of the periods used to form \( \hat{p}_a \) and for the period as a whole.\(^{11}\) The first set of estimates uses all of the variables in equation (9). The second set recognizes that, as shown in appendix 2, responses to \( S \), \( \hat{a} \), and \( \hat{p} \) contain offsetting elements. Since the estimated responses are small and not significant by the usual tests, I omit these variables and retest.

The two sets of estimates have similar implications about the role of money. Current monetary growth has a larger and more reliable effect under the gold standard than under the dollar standard. This difference is consistent with the earlier finding (Table 1) that acceleration and deceleration of the money stock has a large effect on \( \hat{p}_a \) under the gold standard and almost no effect under the dollar standard. The difference is consistent also with evidence that the lag of the rate of price change behind the rate of monetary growth has lengthened in recent years.

The hypothesis suggests a reason for the longer lag. Under the gold standard, price movements were dominantly price changes, not maintained inflation. Expectations were firmly held that the price-specie flow mechanism would reverse the rate of price change. The dollar standard changed performance and anticipations. The rate of price change became less variable and more dependent on the anticipated rate of inflation. Under the dollar standard, rates of price change are much less dependent on changes in money and much more dependent on maintained monetary growth. In this respect, recent price changes are "different" as much of the popular and some academic discussion of inflation insists.

There is another sense in which recent price changes are different. The price-specie flow mechanism predicts a positive relation between prices and output and between rates of price changes and rates of change of output or anticipated output. Table 2 shows that under the gold standard, and for the period as a whole, the data support this implication of the theory. During the years of the dollar standard (equations 9.13 and 9.23), the data reject the proposition. Rates of change of output and anticipated output are negatively related to rates of price change.

\(^{11}\)The procedure used is equivalent to using instrument variables as measures of anticipations, \( \hat{p}_a \) and \( y^a \) in the regressions for the rate of price change. The procedure would be comparable to two-stage least-squares if the regressions in Tables 1 and 2 are regarded as the first stage. The regressions for \( \hat{p}_a \) would then be the second stage. However, I have interpreted Friedman's hypothesis [8] as \( \hat{p}_a = \mu - g \) and have not used any other information about anticipated inflation in the system. Note that the "first stage" estimate would be \( y^a \), not \( \hat{p}_a \).
<table>
<thead>
<tr>
<th>Equation</th>
<th>Period</th>
<th>$\beta$</th>
<th>$\hat{\beta}$</th>
<th>$\hat{\delta}$</th>
<th>$\hat{\sigma}$</th>
<th>$\hat{L}_G$</th>
<th>$\hat{\gamma}$</th>
<th>$\hat{\gamma}^*$</th>
<th>Intercept</th>
<th>$R^2$/D.W</th>
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<td>1901-31</td>
<td>0.28</td>
<td>0.71</td>
<td>0.09*</td>
<td>0.01*</td>
<td>0.08</td>
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<td>0.17</td>
<td>0.20*</td>
<td>0.01*</td>
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<td>0.24</td>
<td>0.14*</td>
<td>0.01*</td>
<td>0.09</td>
<td>0.11</td>
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</tr>
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<td>(9.21)</td>
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<td>0.09</td>
<td>0.11</td>
<td>0.15</td>
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<td>0.09</td>
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<td>-0.03</td>
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<td>-0.16</td>
<td>0.38</td>
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<td>0.65</td>
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<td>0.69/1.16</td>
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<td>0.03</td>
<td>0.65</td>
<td>0.36</td>
<td>0.84/1.98</td>
<td></td>
</tr>
</tbody>
</table>

Note: t-statistics are in parentheses. *indicates computed coefficient is 1/100 of the number shown.
We might dismiss the evidence for the dollar standard as an aberration caused by the small number of degrees of freedom. However, the period of the dollar standard has been a main source of evidence in support of Phillips curves, so I am reluctant to dismiss this evidence. One alternative is to use the coefficients in appendix 2 to interpret the evidence. If the interest elasticity of the demand for money or the response of real rates of interest to $y$ and $y^a$ was smaller under the dollar standard than under the gold standard, positive terms in the coefficients of $y$ and $y^a$ in equation (9) are reduced. Reinforcing these effects was the commitment of foreigners to acquire dollar securities and sell goods to maintain the dollar exchange rate. Lucas's proposition [18] implies that a change from the gold to the dollar standard changes the structural coefficients, so changes in the coefficients arising from changes in the monetary standard and reduced fluctuation in real returns is one plausible explanation. A second alternative is to treat the model as misspecified either because of the presence of an endogenous variable $y$ or the omission of some measure of excess capacity.

Equations (9.21) to (9.24) omit $y$. The explanatory power of the hypothesis falls only during the period of the dollar standard. The negative coefficient of $y^a$ in that period remains. The presence of $y$ in 9.13 does not explain the difference between the dollar standard and other periods.

Popular discussions of inflation suggest that recent inflation is different in yet another respect. Growth of monopoly power in product and factor markets is alleged to be a cause of the "new inflation." The intercept of the $p$ equation has shifted from negative to positive in the recent sample, so the annual rate of price change is now higher for the same rates of change in money and output. Whether the shift is explained by a bias in the price index or some systematic change in the degree of monopoly has not been studied, but it is clear that the shift cannot explain the acceleration of prices after 1965. Moreover, the evidence in Table 2 suggests that the rate of price change is no less predictable than in the past without allowing for any change in monopoly power.

**INFLATION, DEFLATION, AND THE PHILLIPS CURVE**

The Phillips curve relates the current rate of price change to the fully anticipated rate of inflation and some measure of unemployed resources such as the percentage of the labor force unemployed or the gap between current and full employment output. Fully anticipated steady inflation raises the price level at a steady rate, but except in the late stage of hyperinflation, has little effect on real output. Unanticipated inflation increases output by encouraging workers to accept real wages lower than the wages they anticipate. In various forms, this explanation, offered in simple or more complex ways, dominates current discussion of the way in which the economy responds to inflation [5, 11, 15, 24].

The price-specie flow model, as presented here, denies that the full-employment "gap" is a significant determinant of the current rate of price change. Rational agents form anticipations of output, and current prices reflect those anticipations.
When random shocks and unanticipated changes in government policies shift demand, agents revise their anticipations of output and receipts. Actual prices and output adjust to anticipations.

In this section I compare the two explanations for the four sample periods. Comparison of the subperiods provides evidence of any difference between the years of the dollar standard, from which much of the evidence to support Phillips curves has been drawn, and other periods.

Equation (11) is a standard Phillips curve. When current unemployment $U$ equals "natural" rate $\bar{U}$ the actual and anticipated rates of price change coincide.

$$\dot{p} = h_1(U - \bar{U}) + \dot{p}^a,$$

$$h_1 < 0. \quad (11)$$

Since the price-specie flow theory distinguishes between income and anticipated receipts in the determination of current spending, it seems appropriate to distinguish between the anticipated rate of unemployment $U^a$ and the "natural" or full-employment rate $\bar{U}$. $U^a$ is the rate of unemployment consistent with agents' anticipated receipts and decisions to spend. Anticipated unemployment rises as output falls below full-employment output $y_f$. Rational agents use information about the current position of the economy to form anticipations of unemployment up to the point at which the marginal benefit equals the marginal cost of acquiring information.\(^{12}\) Let

$$U^a - \bar{U} = h_2(y - y_f),$$

$$h_2 < 0.$$

Unemployment falls below anticipated unemployment whenever receipts grow faster than anticipated, and unemployment rises when receipts are below anticipations. The reason is that unanticipated changes in receipts change spending and employment.

$$U - U^a = h_3(y - y^a),$$

$$h_3 < 0.$$

Substituting in equation (11), we obtain

$$\dot{p} = h_1 h_3(\bar{y} - y^a) + h_1 h_2(y - y_f) + \dot{p}^a + Z, \quad (12)$$

\(^{12}\) Under my hypothesis it is more appropriate to equate $U^a - U$ to $y^a - y_f$. The reason for not proceeding in this way is to retain the type of measure proposed by those who claim to have isolated a short-run Phillips curve. This introduces endogeneity in the "gap" as measured here, but the response to the "gap" is so small and the significance of the coefficient so tenous that it is doubtful that the use of lags or other steps to remove endogeneity will change the economic implications.
where $Z$ includes current government policies and random shocks. Equation (12) permits a test of the alternatives. If the price-specie flow theory is correct, the principal effects of unemployment are anticipated; $h_1h_2$ is zero, and the full-employment gap has no independent effect on current $p$. The omission of the gap is not a misspecification, and omission of the short-run Phillips curve cannot explain the negative response of $p$ to $\bar{y}$ for 1955-74. A positive coefficient $(h_1h_2)$ on the gap and a positive or insignificant response to $\bar{y}^d$ would support the Phillips curve and strongly suggest misspecification of equation (9).

Table 3 shows the results of the test. Equations (12.11) to (12.14) include the full-employment gap as an addition to equations (9.11) to (9.14) of Table 2. In all important respects, the estimates are unchanged. The response of $p$ to the gap is small and insignificant for the period as a whole. Under the gold standard, unemployment reduces imports and increases exports. The trade balance changes from deficit toward surplus; the base increases, the economy expands, and the gap declines. In the years of the dollar standard, reliance on current-cyclical government policy relates $L_g$ and $\bar{B}$ to the size of the gap if the government increased the absorption of labor and the rate of monetary expansion when unemployment increased. Equations (12.21) to (12.24) retest the response of $p$ to the gap omitting the rates of changes in policy variables. The principal effect is an increase in the coefficient of $\bar{p}^d$ to include most of the response to $\bar{B}$ in (12.11) to (12.14). The effect of the gap falls during the years of the gold standard and remains small and insignificant during the dollar standard and in the period as a whole.

The estimates of equation (12) suggest that the gap contains little information that is not included in the rate of change of receipts anticipated at the start of the year. Since $\bar{y} = \bar{y}^d + \hat{e}_t$, we can interpret the response to $\bar{y}$, given $\bar{y}^d$, as the effect on $p$ of errors in estimating the growth of current receipts. As new information accumulates, both $p$ and $\bar{y}$ adjust. The size of the "gap" between current output and full employment contains no additional information useful for predicting the adjustment, except in years of severe depression.

Recent work by Gordon [11] and by Modigliani and Papedemos [24] claims that, beyond a point often reached in moderate recessions, additions to unemployment have very little effect on inflation. These authors point to the 1930s as evidence to support their conclusion and to argue that rapid monetary growth can be used to raise employment without increasing the rate of price change. The findings here suggest, on the contrary, that $p$ responded to $\bar{B}$, the current rate of monetary expansion in the thirties. Moreover, the annual data show no evidence of any re-

---

13 I estimated several other sets of equations: (1) using only $p^d$ and the gap, (2) adding the gap to equations (9.21) to (9.24) in Table 2, and (3) substituting the gap for $\bar{y}$ and $\bar{y}^d$ in equations (9.21) to (9.24). Although the detail differs, the principal conclusions are unaffected. Substituting the gap for $\bar{y}$ and $\bar{y}^d$ gives a result similar to (12.12) for the period 1901-40. $R^2$ increases (to 0.50), and each billion dollars of gap lowers $\bar{p}$ by 0.001 on average.
### TABLE 3

Tests of the Short-Run Phillips Curve

<table>
<thead>
<tr>
<th>Equations</th>
<th>Period</th>
<th>$\hat{\rho}$</th>
<th>$\hat{\sigma}$</th>
<th>$\hat{\mu}$</th>
<th>$\hat{\theta}$</th>
<th>$\hat{\eta}$</th>
<th>$\hat{\lambda}_g$</th>
<th>$\hat{\gamma}$</th>
<th>$\hat{\gamma}^a$</th>
<th>$y - y_f$</th>
<th>Intercept</th>
<th>$R^2$/D.W</th>
</tr>
</thead>
<tbody>
<tr>
<td>(12.11)</td>
<td>1901-31</td>
<td>0.26</td>
<td>0.71</td>
<td>0.07*</td>
<td>0.01*</td>
<td>0.08</td>
<td>0.13</td>
<td>0.36</td>
<td>0.29</td>
<td>-0.02</td>
<td>-0.02</td>
<td>0.68/2.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.06)</td>
<td>(4.78)</td>
<td>(0.16)</td>
<td>(0.19)</td>
<td>(1.76)</td>
<td>(0.78)</td>
<td>(1.76)</td>
<td>(1.31)</td>
<td>(1.12)</td>
<td>(1.05)</td>
<td></td>
</tr>
<tr>
<td>(12.12)</td>
<td>1901-40</td>
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<td>0.27</td>
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<td>-0.01*</td>
<td>0.08</td>
<td>0.06</td>
<td>0.29</td>
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<td>0.47/2.08</td>
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<td>(0.46)</td>
<td>(1.30)</td>
<td>(2.21)</td>
<td>(0.05)</td>
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</tr>
<tr>
<td>(12.13)</td>
<td>1955-74</td>
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<td>0.18</td>
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<td>-0.57*</td>
<td>-0.09</td>
<td>-0.23</td>
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<td>(1.08)</td>
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<td>(1.28)</td>
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<td>(12.14)</td>
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<td>0.83/1.88</td>
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<td>(2.67)</td>
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**Note:** $y_f$ = potential GNP. $y - y_f$ is in trillions of 1958 dollars. $t$-statistics are in parentheses. * indicates computed coefficient is $1/100$ of the number shown.
liable short-run Phillips curve under the dollar standard. For the period 1955–74, the response of \( \dot{p} \) to \( \dot{y} \) or \( \dot{y}^a \) is negative. Table 3 shows that the negative response cannot be explained as misspecification resulting from the omission of the full-employment gap.

Three explanations occur to account for the difference between the present findings and earlier evidence in support of Phillips curves. First, much of the evidence for the Phillips curve may reflect the way in which the dollar standard operated. Second, larger samples, the use of quarterly or semiannual data, or an alternative measure of the gap may reconcile my results with previous studies. Third, further work may show that the gap is a proxy for the rate of change of anticipated receipts, so that the Phillips curve is a misspecified version of the price-specie flow theory. The last explanation seems most consistent with the results of this study, but until the alternatives are further tested, some doubt remains.

**IMPLICATIONS FOR ECONOMIC THEORY AND POLICY**

The two principal relations of the model are the equations determining anticipated receipts and the current rate of price change. Each specifies a relation between \( p \) and \( y^a \) (or \( \dot{p} \) and \( \dot{y}^a \)). To make the dimensions comparable, differentiate the equation for \( \ln y = \ln y^a \) in footnote 9 and solve for \( \dot{p} \) using the elasticity of \( y^a \) with respect to \( B/p \) evaluated at the sample mean, 0.36. The result is denoted \( AA \) and is shown in Figure 1.

\[
AA: \dot{p} = -2.8\dot{y}^a + 1.14K - 5.00\bar{L} + 0.25\bar{L}_g + 7.36\bar{N} + \hat{B}.
\]

The slope of the \( AA \) curve is relatively steep (-2.8). The position of the curve depends on endowments of capital and labor, monetary policy, and absorption of labor by the government.

**Fig. 1**
The second relation is denoted $BB$. For this relation I have chosen equation (9.24) in Table 2, although the principal results are not greatly changed if (9.14) is used instead. The $BB$ curve has a slope of 0.65; its position depends on $\dot{p}^a, \dot{B},$ and $\dot{L}_g$.

$$BB: \dot{p} = 0.69\dot{p}^a + 0.25\dot{B} + 0.11\dot{L}_g + 0.65\dot{y}^a$$

The two curves determine a position of equilibrium at the intersection of $AA$ and $BB$ in Figure 1. With given anticipations, maintained growth of endowments, a constant rate of participation in the labor force, and constant monetary and fiscal policy, the economy remains in equilibrium.

Suppose, however, the growth rate of the base increases. The $AA$ line initially shifts by a multiple of the shift in $BB$; the elasticity of $p$ with respect to $B$ is unity in the $AA$ equation and 0.25 in the $BB$ equation. The public appears to act on the knowledge that periods of increased monetary expansion are, at first, periods of economic expansion, as the price-specie flow theory implies. Output and anticipated receipts accelerate, and the rate of price change increases.

Maintaining the higher growth of $B$ increases the growth rate of money. The anticipated rate of price change $\dot{p}^a$ depends on the maintained rate of monetary expansion. As $\dot{p}^a$ rises, the $BB$ curve shifts along $AA$ raising the rate of price change and lowering the anticipated and actual rate of change of output. Adjustment of $\dot{p}$ and $\dot{y}^a$ continues until full equilibrium is restored. The $AA$ and $BB$ relations can be solved to obtain the equilibrium output ($yy$) and price ($pp$) relations.

$$yy: \dot{y}^a = 0.22\dot{B} - 0.20\dot{p}^a + 0.04\dot{L}_g + 0.33\dot{K} - 1.45\dot{L} + 2.13\dot{N}.$$  
$$pp: \dot{p} = 0.39\dot{B} + 0.56\dot{p}^a + 0.14\dot{L}_g + 0.22\dot{K} - 0.94\dot{L} + 1.40\dot{N}.$$  

The $yy$ equation is shown as the vertical line in Figure 1.

The $pp$ and $yy$ equations imply that maintained monetary expansion raises the rate of price change proportionally but has no effect on anticipated or actual output. The reason is that the coefficients of $\dot{B}$ and $\dot{p}^a$ are (approximately) equal but of opposite sign in the $yy$ equation and sum to unity in the $pp$ equation. If maintained growth of the base induces a corresponding rate of change of money as in [1], $\dot{p}^a$ and $\dot{B}$ are equal in equilibrium. The steady-state value of $\dot{y}^a (g)$ depends on real variables and is independent of the maintained rate of monetary expansion. The rate of price change rises with the rate of monetary expansion.

The evidence is consistent with some principal propositions of monetary theory. Changes in the rate of monetary expansion induce temporary changes in the growth rate of output—anticipated and actual—but have no permanent effect. Maintained changes in the rate of monetary expansion affect the anticipated and actual rate of price change.

However, the maintained rate of inflation does not depend only on the growth rate of money. Absorption of labor by government contributes to inflation. The steady state effect of labor absorption shown in the $pp$ equation is slightly smaller.
than the estimated effect on $\hat{p}$ in equation (9.24), but both equations suggest that changes in $L_g$ change the price level and changes in $\dot{L}_g$ change the rate of price change.

The $pp$ and $yy$ equations imply that balanced growth in capital and labor with unchanged monetary and fiscal policy is accompanied by rising prices. From the coefficients of the $yy$ equations, we see that whenever $K, L, N$, and $L_g$ grow at the same rate, $\gamma^a$ (and $\gamma$) increases equiproportionally. The $yy$ equation satisfies this standard property of economic models. However, prices rise with constant money stock and balanced growth in capital and labor.\(^\text{14}\) The coefficients of the $pp$ equation imply that equiproportionate growth of $K, L, N$, and $L_g$ raises $p$ approximately 0.8 percent for each 1 percent increase in endowments and unchanged distribution of labor between the private and the public sectors.

The estimates make clear that velocity has increased during the period used for estimation. Attempts to interpret the increase as an adjustment of average cash balances to anticipated inflation are not supported by evidence.\(^\text{15}\) An alternative interpretation is that innovations in cash management are, in part, induced by growth of capital and output. If the productivity of the payments system grows with the economy, improvements in payments arrangements lower the demand for money relative to the demand for capital and relative to output. Steady-state velocity rises as wealth owners equate the marginal product of labor or capital in transactions with the marginal products of labor in the production of goods and services. This explanation has not been tested.

Since the rise in velocity has not been explained as a response to inflation, we cannot conclude that inflation has been entirely a response to money growth. Secular growth in velocity and secular inflation appear to result from maintained growth in capital and labor with unchanged distribution of labor between the public and private sector and from growth in the public sector relative to the private sector.

**CONCLUSION**

The principal conclusions of this paper come from comparison of a standard Phillips curve to the price-specie flow model. The former implies that the rate of inflation depends on some measure of the gap between current output and full-employment output. The latter implies that agents are not surprised by the existence of a full-employment gap and do not respond to the gap. Instead, producers move along their supply curves changing output in response to actual and antici-

\(^{14}\) Claudio Haddad points out that the positive coefficient of $\dot{K}$ in the $pp$ equation may reflect the assumption that $g$ is constant.

\(^{15}\) The response of $\hat{p}$ to $\hat{\pi}$ in equations (9) and (12) is a measure of the effect of adjustment in cash balances to inflation. The effect is zero according to the estimate in Tables 2 and 3. The sign of the coefficients depends on the difference between short- and long-term adjustment, as shown by $w_4$ in appendix 2. A zero value does not deny that long-term adjustment of velocity occurs, but it provides no evidence of the response.
pated spending. When spending increases, prices rise and output increases. The rate of price change varies directly with the rate of change of output or anticipated output and is independent of the level of output. The price-specie flow theory is broadly consistent with propositions advanced in recent work by Friedman [9] and Lucas [19, 20] and with much earlier work by Hume and Thornton.

Data for the century as a whole and for subperiods distinguish between the alternatives. There is substantial support for the price-specie flow theory and less support for the Phillips curve when the theories of inflation are compared. Price changes in the inflation of the sixties and seventies and under the gold standard appear to have resulted from a process that the price-specie flow theory summarizes. Both processes appear to have operated during the depression of the thirties.

There are other differences between periods. A principal difference is in the way anticipations of inflation formed and decayed. Under the gold standard, the anticipated rate of price change rose in periods of monetary and economic expansion and fell during monetary contractions and recessions. Maintained inflation depended on the growth of the world gold stock, not on fluctuations in money resulting from temporary redistribution of the existing stock between countries. Once the gold standard was abandoned, the determinants of the money stock changed, and the relation of money growth to anticipated inflation changed also. The data suggest that the rate of price change became more predictable and the mean rate of change—anticipated and actual—rose.

Several recent discussions of inflation suggest that monetary policy has very little influence on the current rate of price change once unemployment reaches a critical level [11, 24, 29]. Conclusions of this kind are often based on a Phillips curve in which some measure of the full-employment gap is related to the rate of price change. A finding that the effect of the gap on the rate of price change falls as the gap increases is, at best, indirect evidence. The evidence here shows that during the depression of the thirties the mean response of the rate of price change to current and past monetary growth was slightly lower than the response in the rest of the century, but the effect of money on prices did not vanish.

Economic theory implies that sustained monetary expansion, at rates in excess of the growth of output, raises the rate of inflation but has no effect on the steady-state growth of output. My estimates suggest that the growth rate of output is homogeneous of zero degree in the rate of price change, but the rate of price change does not appear to be independent of the rate of growth of output. With steady growth of money and output, the price level rises at a steady rate.

To test Friedman's proposition [8] that inflation is always "a monetary phenomenon," I define anticipated inflation as the maintained average rate of monetary expansion and distinguish between the current rate of price change and anticipated inflation. I find that current and past monetary growth are principal determinants of the current rate of price change. However, if maintained inflation is defined as the average rate of price change, the results deny that inflation has been entirely a response to growth in money. The government contributed to inflation by maintaining the growth rate of public employment above the growth
rate of real output. Further, the evidence suggests that rising prices accompanied growth of capital and labor. Velocity appears to have increased at approximately the rate of growth of output per man. Keeping prices stable, under the circumstances of this century, would have required a reduction of 0.8 percent in the stock of base money for each 1 percent increase in capital, labor, and population.

### APPENDIX 1

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Source</th>
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<tbody>
<tr>
<td>$B$</td>
<td>Monetary base in billions of dollars</td>
<td>1900-17, Friedman and Schwartz [10, table B3], June dates; 1918-40, Brunner and Meltzer series including adjustment for changes in reserve requirement ratio; 1953-74, Federal Reserve Bank of St. Louis</td>
</tr>
<tr>
<td>$L$</td>
<td>Total labor force in thousands</td>
<td>1900-29 [16], table A107, p. 198 (Lebergott series); 1930-70 [16], A108, p. 700; 1971-74, Handbook of Labor Statistics, p. 26</td>
</tr>
<tr>
<td>$L_g$</td>
<td>Government labor force = persons engaged in national economy minus persons engaged in private economy (in thousands)</td>
<td>1900-28 [16], tables A80 and A82, p. 194; 1929-70, tables A81 and A83, p. 194; 1971-74, Bureau of Labor Statistics</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
<td>Source</td>
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APPENDIX 2: COEFFICIENT OF $\dot{p}$

The signs of the coefficients in equation (9) are expressed in terms of the elasticities of the text to make my assumptions explicit.

$$\dot{p} = w_0 + w_1 \dot{p} + w_2 \dot{B} + w_3 \dot{S} + w_4 \dot{a} + w_5 \dot{\bar{g}} + w_6 \dot{\bar{r}} + w_7 \dot{\bar{g}} + v_2. \quad (9)$$

The denominators of the $w_i$ are

$$1 - \{e(V, p) + e(V, r) [1 - e(n, p)]\} > 0.$$

The numerators are...
\[ w_1 = e(V, p^a) - e(V, r) > 0 \]
\[ w_2 = 1 + [e(V, B) + e(V, r) e(n, B)] > 0 \]
\[ w_3 = e(V, S) + e(V, r) e(n, S) \]
\[ w_4 = e(V, \bar{p}^a) - e(V^a, \bar{p}^a) \approx 0 \]
\[ w_5 = 1 + e(V, r) e(n, \bar{L}) > 0 \]
\[ w_6 = e(V, y) + e(V, r) e(n, y) - 1 \]
\[ w_7 = 1 + e(V, r) e(n, y^a) - e(V^a, y^a) > 0. \]

I have assumed that \( e(V, p^a) \) is greater than \( e(V, r) \) in \( w_1 \) and that the bracketed expression in \( w_2 \) is between 0 and -1. \( B \) is used as the measure of current monetary growth.

A value of \( e(n, y) \) substantially above unity makes \( w_6 \) positive. This occurs if the anticipated return to capital is very sensitive to unanticipated changes in current receipts. In this case \( \bar{p} \) and \( \bar{y} \) are positively related in equation (9).

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