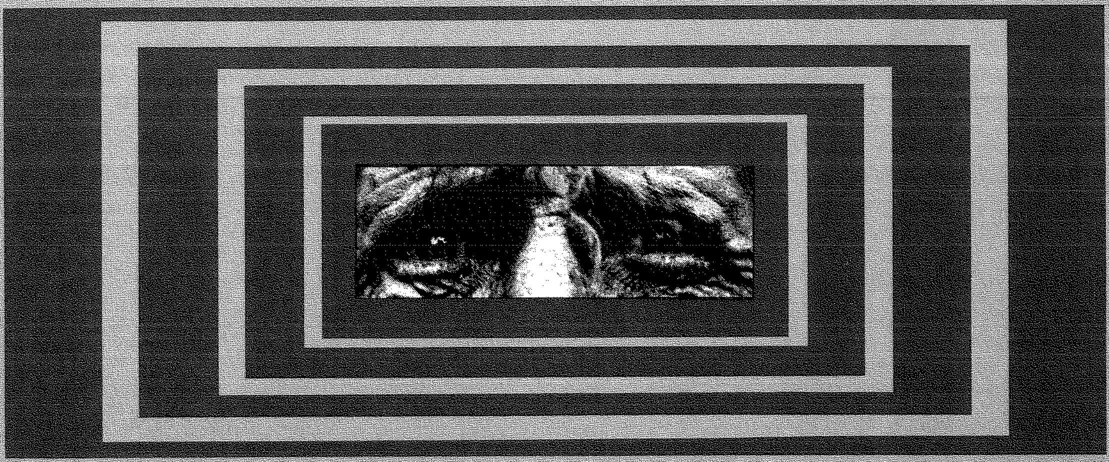
FEDERAL RESERVE BANK
OF SAN FRANCISCO

ECONOMIC REVIEW



ASPECTS OF INFLATION

SPRING 1980

Expectations, Money, and the Forecasting of Inflation

Charles Pigott*

Economists continue to debate whether money is the only or even the primary cause of inflation. Few, however, would deny that money affects inflation with a lag. This proposition has been confirmed by studies of a variety of countries and historical periods. In most cases, money's effect upon prices has been found to continue for several years' time, although the precise lag often seems to vary substantially.[1]

Partly as a result of these studies, estimates of the lagged relation between money and prices are widely used for such purposes as forecasting inflation. But this lagged relation has implications that go well beyond the prediction of inflation. If money changes are not immediately and fully reflected in prices, they will lead in the short run to variations in real balances and real liquidity, which in turn may affect interest rates and real aggregate demand. Indeed, it is widely believed that money affects real economic activity in the short run because its impact upon prices is delayed.[2] This view is reflected in many of the formal econometric models used in business and government, where the timing of money's impact upon prices is critical in determining short-run effects of monetary policy on the real sector.

But despite its widespread application, little is known empirically about the factors determining the money-inflation lag. Indeed, the very reasons for its existence are controversial. A common and traditional view is that the lag stems from institutional and technical factors— e.g., contracts and adjustment costs— that prevent prices from adjusting immediately to money changes. Also, according to this view, such factors presumably are unaffected by monetary policy. This proposition, if true, greatly simplifies the task of policy analysts, since it implies that estimates of the money-inflation relation derived under one type of policy will remain valid under another. Past behavior, that is, provides a relatively unambiguous guide to the future in this case.

In recent years, with the growing understanding of the influence of individuals' expectations upon behavior, such mechanistic views of the lags in economic relations have been challenged. Few would deny that institutional and technical "frictions" such as contracts, adjustment costs, and imperfect information are partly responsible for the lag between money and prices. Nonetheless, basic economic theory suggests that the decisions individuals make when faced with such factors often depend critically upon their anticipations about the future. In some industries, for example, contractual arrangements prevent prices from adjusting immediately to a change in money. It could be supposed that anticipations have little or no influence upon the length and general form of such contracts, since these features often are largely determined by custom, law, and industry characteristics. But the price specified in any contract will depend upon firm perceptions of future costs and demand, and hence implicitly upon judgments about future inflation and (thus) monetary policy.

This suggests that the lags in money-inflation as well as other economic relations result from the interaction of two basic sets of fac-

*Economist, Federal Reserve Bank of San Francisco. Kirk McAllister and Christopher Dunn provided research assistance for this article.

tors. On the one hand, there are various "frictions" and "imperfections"—factors that are determined largely by technology, precedent, law, and other institutional characteristics that change very slowly with anticipations, and then only if these depart fairly radically from past experience. But interacting with these factors are individuals' expectations, particularly their perceptions as to how current and past conditions relate to those in the future. Given that interaction, the lag between money and prices (and analogous lags in other economic relations) is likely to change when government policies are altered, because then individuals' expectations can be expected to change.

Plainly then, the extent to which expectations influence the money-inflation lag has potentially far-reaching practical implications for policy formulation. If expectations are important, the relations used to predict inflation and real-output responses to money are apt to shift when basic policy is altered. To assess the effects of alternative policies realistically, we are likely to need an explicit identification of the role of expectations in determining the money-inflation lag, because only in this way will we be able to predict shifts in the relation. If expectations are as important as some economists believe, policy analysts will have to consider them more explicitly than they generally have in the past.

This paper discusses how expectations about monetary policy may affect the lag between money and prices. Basically, we argue that price decisions made now are likely to be based upon individuals' anticipations about the level of money in the future. If true, the consequences are very important for the forecasting of inflation, the evaluation of prospective policies, and the testing of alternative theories of inflation. Normally, inflation forecasts are based upon data on current and past money growth and, in some cases, other variables; the same relations are usually employed in predicting the impact of prospective policies. If prices are actually based upon forecasts of future money, such relations will reflect the way in which predictions of future money are calculated from current and past data. For this reason, basic changes in monetary policy are likely to alter the lag between money and prices, because such changes are likely to lead individuals (at least eventually) to revise their forecasting methods. Following Lucas (1970) and Sargent and Wallace (1976), our arguments criticize those procedures which use economic relations observed under one set of policies to predict the consequences of different policies.

Section I of the paper summarizes explanations that have been offered for the lag between money and prices. Nearly all of these explanations suggest that prices will be based, directly or indirectly, upon forecasts of future money (see appendix for technical details). Estimates presented for several countries suggest, tentatively, that expectations may have significantly influenced money-inflation lags. For policy purposes, however, we must identify the way in which expectations affect such empirical relations between money and prices; only then can we determine how inflation-forecasting methods must be revised when policy is altered.

In Section II we discuss the implications of a relatively simple but potentially powerful hypothesis—that prices respond more to money changes that are perceived as permanent or persistent than to those seen as transient, with that response itself being relatively unaffected by policy. This suggests that the empirical relation between inflation and actual money will depend crucially upon how individuals view the future sustainability of such changes in money. The (crude) evidence cited here provides only mixed support for this view, but the hypothesis merits further research.

I. Lags Between Money and Prices

In the long-run, it is widely believed, sustained changes in money merely lead to variations in all prices in the same proportion without affecting real output, interest rates, or relative prices. ("Sustained" changes are those that are neither augmented nor diminished in the future.) This proposition, which is known as the (long-run) neutrality of money, is based intuitively on the fact that a rise in money and all prices in the same proportion leaves the "typical" individual's real balances, real wealth, and real income unaffected; since that individual's consumption, savings, work, and leisure opportunities are unaltered by the money change, his decisions similarly should not be affected.[3] A substantial amount of evidence suggests, at least for the U.S., that money is at least approximately neutral in this sense.[4] Of course the neutrality of money does not imply that money changes are the only sources of change in the aggregate price level; it is also affected by changes in real income, interest rates, oil prices and other variables which influence the demand for money. However, historical studies, particularly the monumental *Monetary History of the United States* by Friedman and Schwartz (1963), have established that variations in money growth account for most variations in long-term inflation rates.

This long-run relation suggests the use of money to predict inflation in the short-run. However, even casual observation reveals that money changes do not lead immediately to proportional changes in the price level, but that they are associated initially with changes in real output and interest rates. Most economists would agree that this short-run departure from neutrality originates in factors that prevent prices from responding immediately and proportionately to money changes, and that the subsequent change in real balances leads to interest-rate and real-output changes that further influence the "transmission" of money to prices.

More formally, we can distinguish between long-run and short-run effects. In the long-run, prices vary proportionately with nominal aggregate demand, which itself changes in the same proportion as money. In the short-run, however, money is not fully reflected in prices, but "spills over" into real income and interest rates, which in turn influence aggregate demand and prices. This series of adjustments of prices to money, direct as well as via money's effect on output and interest rates, is reflected in relations used to predict prices and inflation from money-growth data. Such relations are commonly written in the form,

$$p(t) = a_0 m(t) + a_1 m(t-1) + \ldots a_n m(t-n) + z(t) \tag{1}$$

or more commonly in change-form as

$$\Delta p(t) = a_0 \Delta m(t) + a_1 \Delta m(t-1) + \ldots a_n \Delta m(t-n) + \Delta z(t) \tag{1'}$$

where p is the log of aggregate prices, m is the log of the money stock, and z(t) stands for all other non-monetary variables affecting prices, such as long-run trends in real output and money velocity; here $\Delta p(t)$ refers to the change in p(), that is p(t)-p(t-1) and similarly for $\Delta m(t)$.[5] Again, the lags reflect not only money's direct effect upon prices but also its indirect effects operating via short-run changes in real output and interest rates.[6] What is the source of these lags, and how may they be influenced by individuals' expectations about monetary policy?

Reasons for Lags

Until recently, lags between money and prices were commonly explained as reflections of disequilibria in commodity and labor markets. According to this essentially Keynesian approach, prices and quantities in a market generally differ from their equilibrium values as determined by the intersection of market supply-and-demand schedules. In this view, prices and quantities adjust gradually and fairly mechanically toward their equilibria in response to excess demand—the gap between demand and supply at current prices. Money thus affects aggregate demand initially, with prices responding only later and gradually to the resulting excess demands in commodity and labor markets. This adjustment process was (at least implicitly) supposed to depend upon institutional features of the market, and not upon monetary policy or expectations about it. However, economists have become increasingly skeptical of this view, since it implies that producers deliberately prolong a state of excess demand even when they are free to vary prices.[7]

More "modern" explanations of the money-inflation lag suggest the potentially crucial nature of individuals' expectations about policy. According to one argument, prices fail to respond immediately and fully to money changes because of an *information lag* between the time a change in aggregate money occurs and the time individuals find out about it. Under this view, money changes that are perceived by individuals are immediately and fully incorporated in prices, with no effect upon real output; perceived money changes, that is, are neutral even in the short-run. However, because of lags in the publication and dissemination of government statistics, individuals generally do not know the level of the current money stock, but must estimate its value based upon their knowledge of current and past economic conditions. When their estimates are "incorrect," actual aggregate demand will differ from the level perceived by consumers and firms. For example, when money rises by more than is anticipated, a typical firm experiences an increase in demand for its product that is apparently greater than the increase it perceives in aggregate demand. Consequently, firms generally raise real output in response. But because of the adjustment costs involved in varying output and employment levels, firms usually will need a considerable amount of time to return to their original levels of output, even after they find out the true level of the money stock. These output changes in turn may account for the protracted response of observed money-price effects.[8]

Another explanation of the delay in the monetary impact emphasizes lags in the response of aggregate demand itself. Specifically, individuals may shift their demands more in response to changes in money that are viewed as persistent than to transient changes. This suggests that aggregate demand will vary proportionately with the average of current and past money growth— the best reflection of permanent money changes—rather than only to changes in the current money stock. Furthermore, aggregate demand may be influenced by interest rates, which respond to expectations of future inflation. This means that current aggregate demand will depend upon expectations of future money growth—the likely basis of expectations of future inflation—and thus indirectly upon observed current and past money changes (to the extent they indicate future money changes).[9] In either case, there may be a lag between money and prices, even when prices respond immediately and fully to current aggregate demand.

Neither of these explanations involves any impediments to the adjustment of prices to aggregate demand. In practice, however, such impediments almost surely exist. In some industries, for example, prices and wages are set for protracted periods by contracts which contain only limited indexing provisions. In many activities, furthermore, prices are constrained by implicit agreements that limit the frequency of price changes. For example, when a department-store chain mails out a catalogue it makes a tacit agreement to honor the listed prices—even when it is not legally bound to do so. Why do firms voluntarily limit their price responsiveness to current demand conditions? One important motivation may be the customer loyalty that firms gain by offering a more stable and predictable price than they would offer if they responded to every shift in demand.[10] In any case, firms that set fixed prices over a certain period are likely to forecast the level of demand for that period, which means that they will (at least implicitly) make judgments about future levels of the money stock.

Expectations and Inflation Prediction

All except the first of our explanations of the money-price lag imply that current prices depend, directly or indirectly, upon firms' and individuals' forecasts of money over some (generally considerable) future interval. This is perhaps most obvious when prices are fixed by explicit or implicit contracts, because price setters then will have to assess the probable level of demand prevailing over the contract life. But producers' judgments about the division of current money into transient or permanent components also involve predictions about future money. Furthermore, producers' strategies about changes in future output levels, in the interval before prices respond fully to money, are likely to depend upon their projections of future money.[11]

The implications of this money-price relation for predictions of inflation depend crucially upon how the forecasts of future money are made. Let us assume that predictions of future money are based entirely upon past observations of money growth. Then, the above analysis suggests, the timing of money's effect upon prices depends upon two sets of factors: a) Rigidities and imperfections that are largely determined by institutional structures, precedent or law, and/or technical factors that are largely unaffected by all but drastic changes in expectations and policy. (Examples are contracts, costs of adjusting output and employment, and factors generating incomplete information about conditions relevant to individuals' decisions); and b) The relation used by individuals to forecast future money, in particular the relation they perceive between already observed money changes and those they anticipate in the future.

It follows that money-price relations, such as (1), are likely to remain unaffected by monetary-policy changes only if individuals do not change the way they forecast future money. But this is unlikely to be the case in the event of major policy changes; however crude their forecasting techniques, individuals are likely to adapt their forecasts eventually to changing conditions.[12]

Also, according to this view, information on variables that do not directly affect prices but which aid individuals in predicting money should be useful in predicting current as well as future inflation. Sunspot activity is unlikely of itself to affect aggregate prices—but if sunspots are useful in predicting future money, analysts must take them into account in assessing current and future inflation developments. In other words, knowledge of the factors that *directly* cause price changes is only a partial guide to their prediction.[13]

Some Evidence

Analysts normally develop inflation forecasts from relations similar to (1) without explicitly accounting for individuals' expectations. Frequently they estimate the forecasting relation on the basis of data for all or most of the post-World War II period; the result then reflects some "average" of the monetary policies prevailing over the entire period. But as our analysis suggests, this procedure may lead to seriously biased inflation forecasts if monetary policy has changed substantially and if individuals' expectations have changed to reflect this fact. The appropriate relation for forecasting inflation may be unstable, that is, may vary over time.

How important a practical problem this presents is an empirical question. The lag between money and inflation may primarily reflect institutional factors and adjustment costs, rather than expectations, in which case the lag should not vary perceptibly with policy. Alternatively, policies themselves may not vary substantially over time; or expectations about policy may change only very gradually. If any of these statements are true, relations such as (1) may not be very different now from what they were twenty years ago.

A direct, although crude, way to measure the role of expectations is to see how money-inflation relations vary from period to period. This we have done with the relation between quarterly consumer-price changes and current and past money growth for several industrial countries, including the U.S., for the 1961-78 period as well as two sub-periods, 1961-70 and 1971-78 (Table 1). We used the "narrow" (M-1) definition of money, partly because data for the entire period were available only on that basis.[14] In deriving these estimates, we included an additional variable —an average of the current and eleven previous quarters' growth in real balances—to help correct for variations in the trend of real money demand arising, for example, from financial innovations. (A similar correction is used in the Keran-Zeldes article in this *Review*). Also, to help correct for the effects of oil-price increases on real income growth, we included a dummy variable for the period 1974-78.[15]

The choice of sub-periods reflects the different international monetary arrangements in force during those two periods. From 1961 through 1970, foreign countries' monetary policies were constrained by the need to maintain a fixed value of their currency in terms of the dollar. Under the then-prevailing dollar standard, foreign inflation rates could not differ from U.S. inflation rates over the long run. After 1970, however, U.S. and foreign inflation rates increasingly diverged, leading by 1973 to a complete breakdown of the fixed-exchange-rate system. Thus monetary policies abroad (at least) may now be less constrained than they were in the earlier period, which raises the question whether this shift is reflected in the money-inflation relation for these countries. The crudeness of our estimates reflects the use of several simplifying assumptions. In particular, we assume that non-money factors affecting inflation (not captured by the money-demand correction) varied at a constant average rate during the estimation period, and that deviations from this rate were unrelated to money growth.[16] This and other simplifying assumptions may account for some of the anomalies of the results.

Our results suggest that the long-run impact of money on prices frequently is significantly different from unity. This might appear to contradict the proposition of money neutrality, which implies that an increase in money that is sustained will eventually raise all prices in

Table 1
Relationship of Inflation and Money Growth 1961–78

	Belg.	Can.	France	Ger.	It.	Japan	Neth.	Switz.	U.K.	U.S.
1961.1–1970.4										
Money Demand Trend[5]	–.57	.13	.07	–1.16	–.55	–.97	–2.51	.19	–1.26[2]	–1.10[2]
Long-run Money Impact	.63[2]	.15[1]	–.39[1]	1.17[2]	1.34[3]	.59	–.07[1]	–.17	1.16[2]	1.26[2,1]
Adjusted R^2	.25	.55	.23	.23	.21	–.03	.28	.01	.37	.88
1971.1–1978.4										
Money Demand Trend[5]	–.009	.16	.48[2]	–.78[2]	–1.23[2]	–1.28[3]	–1.08[2]	–1.19[2]	–.71[2]	–.66[2]
1974–78 Shift Term[6]	–.012[3]	NI	–.020[2]	–.006[2]	NI	.023[2]	–.009[2]	NI	NI	NI
Long-run Money Impact	3.15[2]	.26[1]	2.11[2]	1.49[3]	2.58[2,1]	2.39[2]	2.90[3]	1.18[2]	–.14[1]	4.99[2,1]
Adjusted R^2	.69	.55	.79	.60	.50	.55	.51	.77	.65	.75
1961.1–1978.4										
Money Demand Trend[5]	–.20	.06	–.04	–.73[2]	–.50[2]	–.41	–1.04[2]	–.62[2]	–.45[2]	–.04
1974–78 Shift Term[6]	–.009[3]	NI	.002	–.005[2]	NI	.020[2]	–.008[3]	NI	NI	NI
Long-run Money Impact	1.00[3]	.22[1]	.01[1]	1.21[2]	2.06[2]	1.38[2]	.73[3]	1.16[2]	–.04[1]	1.56[2]
Adjusted R^2	.50	.80	.67	.52	.68	.40	.29	.58	.73	.82
F Test for Homogeneity	5.65[4]	1.61	5.41[4]	3.79[4]	1.94	2.08	3.68[4]	2.52[4]	3.48[4]	5.46[4]

NI: Not included (see note 6).
[1]Significantly different from unity at the 5% level.
[2]Significantly different from zero at the 5% level.
[3]Significantly different from zero at the 10% level.
[4]Indicates that the null hypothesis that all the slope coefficients are the same in the two periods can be rejected at (at least) the 5% level.
[5]Defined as the average long-run growth of real balances over the current and previous 11 quarters.
[6]Included in the reported results only if its value was significantly different from zero at the 10% level; otherwise the equation excludes the variable.

proportion. Of course, such sustained increases would be typical only under certain monetary policies; current money increases often will be followed by offsetting or reinforcing money growth in the future. But if the money-inflation relation is the same regardless of the choice of monetary policy, and if money is neutral, the long-run impact of money on prices should be unity—since it should be the same under one policy as under any other. Yet as shown below, this impact will generally not be unity if the lag between money and prices is influenced by anticipations about future money growth. Our finding thus provides indirect evidence that anticipations help determine the timing of money's effect upon prices.

Further evidence (again indirect) is provided by the apparent significant shift in the money-inflation relation between the two subperiods; the hypothesis that the relation is the same for both is nearly rejected for Italy and Japan, and is easily rejected for all other countries except Canada. This finding is particularly striking in view of the fact that the long-run impact of money on prices generally increased from the first subperiod to the second. (However, this is not true of the U.K., where the later-period results are rather implausible). This might be expected, however, because we may suppose that foreign countries' money growth was substantially constrained by U.S. growth during the period of fixed exchange rates.

The evidence in Table 1 is thus consistent with the proposition that expectations influence the money-inflation lag. The relation appears to shift between the two subperiods, possibly reflecting the difference in constraints on foreigners' monetary policy. In addition, the long-run impact of money on prices often does not equal unity, as would be the case if the relation were valid under any monetary policy. This evidence is far from conclusive, however, particularly as there are other possible explanations of the apparent shift between the subperiods. In particular, autonomous domestic price changes themselves may have served to reduce domestic money via international reserve changes during the fixed-rate period; and such feedback from domestic prices to money could bias our estimates downward. Preliminary tests indicate that such an influence may have been important for Germany, Japan, and the U.K. during this period, although it was less significant (if at all) for the other countries considered.[17]

II. Response to Permanent and Transient Money Changes

The mere observation that expectations can cause money-inflation relations to vary is of little use for practical policy analysis. To improve inflation forecasts, we must know precisely how expectations affect the timing of money's impact upon prices, as well as how these expectations are determined. This is potentially a very difficult task, especially as anticipations may interact with other sources of the money-inflation lag in complex ways.

Nonetheless, our arguments suggest a simple but potentially powerful explanation of the lagged relation between prices and money. This explanation is based upon the hypothesis of a stable relation —one unaffected by monetary policy—not between prices and actual money, but between prices and that part of money changes perceived as persistent or permanent. In this view, prices respond more to the permanent than to the transient part of money variations. Even if only approximately correct, this view provides some useful guidelines as to how inflation forecasting relations should be altered when policy is substantially changed. This approach and its implications are described in detail below, with a more technical development left to the appendix.

Prices and Permanent Money

An earlier argument suggested that prices in individual industries are based upon an average of the level of money expected to prevail over some future horizon. Consider, for example, the situation confronting a firm which must fix its price by contract for several periods. The demand for the firm's product over the life of the contract may be primarily determined by the level of aggregate demand which (to simplify matters) we may assume varies proportionately with the money stock. Now if the firm sets too high a price relative to expected demand, it will be unable to sell all it produces and thus must carry inventories at some cost; if it sets too low a price, it will have to delay deliveries, speed up production schedules, and/or draw down inventories from desired levels, all of which entail additional costs. Hence the firm may try to set an average price that would ensure that sales equal output over the contract period.[18] This average will then depend upon the expected level of aggregate demand over the contract period, so that in setting its price the firm must forecast some average of the money stock over its planning horizon. Alternatively, suppose that all prices vary simultaneously with aggregate demand, but that (nominal) demand depends upon individuals' expected "permanent" level of money—that is, upon an average of the money balances they expect to have now and in the future. It should be clear, at least intuitively, that prices again will depend upon an average of money levels expected in the future. (The appendix demonstrates this point, and also demonstrates that the dependence of aggregate demand upon interest rates is likely to lead to a similar conclusion).

Suppose then that prices in industry "i" vary proportionately with an average of the level of money expected now and in the future. This average (permanent money) can be written without any essential loss of generality as,

$$m^*(t) = \frac{1}{n+1}\,[m(t) + {}_t m^e(t+1) + {}_t m^e(t+1) + \ldots {}_t m^e(t+n)] \quad (2)$$

where $m^*(t)$ is the logarithm of permanent money, $m(t)$ is the log of the current aggregate money stock, and ${}_t m^e(t+j)$ is the log of money currently (at t) anticipated j periods in the future. In other words, $m^*(t)$ is individuals' current anticipation of the average level of money over their future planning horizon.[19]

It follows that prices in industry "i" will vary proportionately with permanent money, or,

$$p_i(t) = m^*(t) \quad (3)$$

where $p_i(t)$ is the log of industry i's price. (To simplify the discussion, we may neglect all other factors affecting the demand for and supply of firm products.)[20] Since the aggregate price level is simply an average of industry prices, it too will vary proportionately with permanent money; more precisely, if all anticipated future money stocks rise by a given proportion, the aggregate price level will eventually increase by that proportion. However, when prices are set by contracts, the response of the aggregate price level to a change in permanent money is likely to be substantially slower than that for an individual industry. In a contract situation, some prices composing the current aggregate price index, having been set earlier, will be based upon past permanent money; thus the aggregate price level will respond to an average of current and past permanent-money levels.[21]

The pricing strategy outlined above tends to diminish the impact of perceived transient money changes on inflation. That is, monetary variations which individuals view as transient have little or no effect upon their estimates of permanent money, and thus little effect upon prices. In principle, this general strategy is sensible whatever policy is followed by the monetary authorities. Of course, the exact relation between aggregate prices and permanent money depends upon firms' forecasting horizons, which influences their calculation of permanent money, and depends also upon contract durations and the timing of renewals—all of which could be affected by monetary-policy decisions. However, these characteristics are based upon industrial-organization patterns and other institutional features that generally change slowly and that generally remain unaffected by all but the most dramatic policy shifts. Thus, at least upon examination we may view relation (2) as invariant to expectations about policy.

Forecasting Inflation

What are the consequences of our permanent money-price relation for the prediction of inflation? Normally analysts use current and past data in forecasting future prices and thus inflation—because, after all, expectations are not directly observable. In our view, however, prices do not respond directly to actual money, but only to individuals' perceptions of permanent money.

Nonetheless, current and past money data may be useful in predicting inflation, because individuals normally use such data in forecasting future money and thus in assessing permanent money. Relations between inflation and current and past money growth, such as (1′), then reflect individuals' perceptions of how observed money changes relate to future, and therefore permanent, money. In other words, an inflation forecaster must "predict" individuals' perceptions of permanent money, and in particular determine how individuals use current and past money in anticipating future money.

In practice, we are not likely to know exactly how individuals calculate permanent money. However, individuals are likely to learn, by observation, how a particular monetary policy operates—provided it has been followed for a long-enough period of time—and thus their forecasts of future money will tend to reflect the way money has actually behaved. Analysts can follow the same thought processes, and thus can estimate what individuals' expectations will be in the context of any specific monetary policy.

The impact of past money on inflation accordingly reflects the way in which permanent money is calculated. This conclusion has important consequences for the relations we have used to forecast prices. If our view is correct, the long-run impact of money on prices apparent from these relations will not generally be unity (even assuming that money is neutral); rather the measured impact will be that of current money on permanent money.[22] Imposing the constraint of unity could lead to misleading inflation forecasts except under certain limited policy conditions. In contrast, our approach could provide a possible explanation of the changes in the impact of money on prices observed between the 1960's and 1970's (Table 1).

Consider, for example, a situation where individuals know that the monetary authorities have adopted a certain target path for money, and also know that the authorities will correct for deviations from the target path in the period following any such misses (Figure 1, Case 1). Changes in money that bring its level above or below the target path are then transient; that is, they exert virtually no impact on permanent money. Indeed, individuals in any period will expect that money will be on target by next period. Apart from this path, current inflation will be unrelated to past money growth—since this provides no additional information about future money and thus very little about permanent money—and the measured long-run impact of money on the price level will be essentially zero.

Now consider a policy situation where money changes are purely random. Imagine, for example, that money growth is determined by the spin of a roulette wheel, with money growing by the winning number when it is red

Figure 1
Effects of a One-Percent Increase in Money (Above Its Long-Run Average Rate)

Effect on:	Case 1 (Money Change Viewed As Transient)	Case 2 (Money Change Expected to be Sustained)	Case 3 (Money Change Expected to be Followed by Further Changes)
Forecasts of Future Money	Do not rise	Rise by one percent	Rise by more than one percent
Permanent Money	Increases by (much) less than one percent	Increases by one percent	Increases by more than one percent

and declining when it is black. Average money changes will then be zero, but at any given time the level of money expected in the future will be the same as what is now prevailing (Case 2). The level of expected future money, and thus permanent money, will then shift up and down with current money growth. That is, a rise in current money will signal an increase in permanent money and thus a proportional increase in prices. Inflation and current money growth will certainly be related— and inflation may also be related to past money growth if contracts prevent some industries from adjusting immediately—and the long-run impact of current money growth on prices will be unity.

Finally, consider the case where money growth exceeds its long-run average and remains above target in succeeding periods. Individuals perceiving this pattern will then raise their estimates of permanent money more than proportionally whenever they observe money growth rising (Case 3). Such accelerations generally will lead eventually to more-than-proportionate increases in the price level, so that the measured impact of money on prices in this case will be greater than one.

To summarize, we argue that a money-price forecasting relation reflects the way in which individuals predict future money, not primarily the causal links between money and prices.[23] If true, this has several important implications for the forecasting of future prices, and hence inflation. First, the total effect of money on prices measured from such relations generally will not be unity, and should not be constrained to be so. The more persistent the current money changes, the more they will ultimately affect prices. Second, when other variables, such as government deficits, provide information about both past and future money, they should be used in the forecasting of inflation. Even if money were the only direct cause of inflation, accurate predictions of prices generally will also involve other variables; in other words, because of the complex social and political nature of inflation, individuals should rely on more than the past history of money in predicting its future.[24]

How important are these considerations in practice? Consider the case where the monetary authorities switch from a policy of offsetting monetary deviations to one of constant accelerated growth. So long as individuals continue to predict future money as before, inflation forecasters utilizing data based on the initial policy will continue to be reasonably successful. But once individuals learn of the new policy, the old forecasting relation will seriously underpredict inflation. This relation will predict relatively small price responses because it is based upon a period in which money changes were normally transient; once individuals learn that new money changes are more permanent, actual price responses will be much greater.

Evidence Reconsidered

Our arguments help explain certain features of the money-inflation relation summarized in Table 1. As we saw, the long-run impact of money on prices was greatest for the U.S. Furthermore, the long-run impact was generally higher during the 1970's than during the 1960's; the impact generally was below one during the 1960's, but equal to or above one during the 1970's. However, our permanent money-inflation theory suggests an explanation for this shift, based on the different international monetary arrangements prevailing during the two decades.

During the 1960's, foreign nations attempted to maintain a fixed value for their currencies in terms of the dollar. Such a policy required that foreign prices rise at the same rate as those in the U.S., at least on average. This in turn meant that foreign money growth was effectively constrained by U.S. growth. If foreign money growth was too high, for example, prices of traded goods produced abroad would tend to rise faster than those in the U.S., eroding the competitiveness of foreign industries. The resulting trade and balance-of-payments deficits then would render such a policy incompatible with maintenance of a fixed exchange rate. In effect, foreign money growth had to follow a path determined by U.S. money, at least in the long-run. U.S. monetary policy, on the other hand, was much less constrained by its balance of payments, in part because our economy was much less open than abroad, and in part because U.S. dollars were the primary reserves held by foreign central banks.

Under these circumstances, foreign money changes that diverged from U.S. money growth could not persist indefinitely. Perhaps a significant portion of money growth abroad was viewed as transitory; if so, this could explain why the long-run effect of money on prices abroad was generally below unity (and below the U.S. figure) during this period. Also, perhaps U.S. money growth provided information about the future direction of foreign money growth, in which case it should have been useful in forecasting foreign inflation as well. Logue and Sweeney provide indirect evidence of this, by finding that foreign nominal income changes were frequently explained much better by foreign *and* U.S. money growth than by foreign money changes alone.[25]

During most of the 1970's, in contrast, countries were not officially committed to maintaining fixed exchange rates, so that in principle, foreign nations were able to vary their money supply independently of any U.S. actions. A higher proportion of foreign money changes thus could be viewed as permanent, which might help account for the fact that the long-run effect of money now appears generally to be higher than before.[26] On the other hand, all countries do not exploit their monetary independence; some have adapted their policies to others in an attempt to limit fluctuations in the value of their currency. Canada's policy, for example, has been designed in part to limit variations in the value of its currency in terms of the U.S. dollar, even during the 1970's. Not surprisingly, then, the long-run impact of money on prices apparently remains below one, and although higher than the 1960's, is not substantially so.

Our explanation assumes that money changes now are generally regarded as more persistent—that is, with greater impact upon permanent money—than they were in earlier periods. But is this really the case? To answer this question would, ideally, require the identification of the exact relation used by individuals to estimate permanent money. This is a formidable task, because the process determining money growth depends upon a variety of factors, and also involves an unknown time horizon.

Nonetheless, we can make crude approximations by estimating the extent to which a money change typically is offset or reinforced in subsequent periods; this can be estimated from the pattern of money growth observed over the period in question. Specifically, what is the cumulative total of future money changes that typically follows a rise in current money above its long-run average—that is, how much would we expect the money stock to rise ultimately as the result of an initial increase? This long-run impact should be relatively small when money changes are largely transient (i.e., offset in the future). Hence, in our view, the impact might be larger during the floating-rate period than during the fixed-rate period; it might also be higher for the U.S. than for other countries during the earlier (fixed-rate) period.

Admittedly, this is a crude measure of the effects of past upon permanent money. In particular, a pattern where a current increase is followed by further changes, but ultimately is completely offset, could substantially affect permanent money if price-setters' horizons are sufficiently short. For this reason, it will also be useful to examine how the level of the morey stock varies in the quarters following the initial shock.

To measure these impacts, we have fitted a simple (univariate) time-series model of money-supply changes for each country for two periods, 1958-67 and 1968-78, again using quarterly (seasonally adjusted) data. Note that each of these periods begins several years before the corresponding intervals used to estimate the results reported in Table 1. This was done because of the assumption that individuals would require some time to observe the behavior of money before arriving at a final notion of how to predict it; thus the relations estimated over these earlier periods may better reflect individuals' expectations than relations estimated for later periods. We then have the following:

$$\Delta m(t) = c + a_1\Delta m(t\text{-}1) + a_2\Delta m(t\text{-}2) + \delta(t\text{-}1) + b_2\delta(t\text{-}2) + b_4\delta(t\text{-}4) \qquad (4)$$

where $\Delta m(t)$ is the quarter-to-quarter change in the logarithm of money. This relation can also be written in a form where current money growth depends upon past money changes and the current value only of $\delta(\ )$.[27] In this, $\delta(\ )$ stands for money changes in excess of those already anticipated on the basis of past money changes. Its meaning can be seen from the computation of the impact of money growth on the level of money in the long-run (Table 2). Assume that money, after growing steadily at its long-run average rate, rises by one percent more in the current period; then $\delta(\ )$ is equal to one percent. The long-run effect of this increase on the level of money then equals the sum of the current and future money changes generated by this "blip" in money growth; it equals $(1 + b_1 + b_2 + b_4)/(1 - a_1 - a_2)$. Of course this ultimate impact will take some time for completion, and indeed this in-

Table 2
Summary of Univariate Time-Series Estimates for Changes in Log Values of the Money Supply[3]

	1958.1–1967.4			1968.1–1978.4		
	Long-run Effects[1]	F[2]	Adjusted R^2	Long-run Effects[1]	F[2]	Adjusted R^2
Belgium	.59	2.1	.12	6.8	2.8	.17
Canada	.53	4.6	.30	26.4	3.1	.20
France	8.0	7.4	.43	3.3	3.5	.22
Germany	1.9	2.3	.13	3.3	2.3	.13
Italy	1.2	5.0	.32	2.4	3.4	.22
Japan	1.1	8.5	.47	14.8	4.1	.27
Netherlands	1.2	2.3	.13	3.2	2.9	.18
Switzerland	5.3	1.3	.04	5.0	2.2	.12
United Kingdom	1.5	5.0	.32	2.4	2.2	.13
United States	.33	4.3	.28	2.3	4.9	.31

[1]Ultimate effect upon future money of a 1-percent unanticipated change in current money.
[2]Test of the significance of the entire set of parameters. A value above 2.3 is significant at the 5-percent level.
[3]The model contains moving average parameters at lags 1, 2 and 4 and autoregressive parameters at lags one and two. Thus the model can be written as,

$$\Delta m(t) = a_0\Delta m(t-1) + a_1\Delta m(t-2) + \delta(t) + b_1\,\delta(t-1) + b_2\delta(t-2) + b_4\delta(t-4)$$

where $\Delta m(t)$ is the quarterly first difference of the log of M1, and the $\delta()$ are white-noise errors.
[4]For Canada for the first period, the estimated model is (barely) unstable in the sense that the changes in money following the initial increase persistently grow in absolute value (however, the estimates are fairly 'close' to being stable). When the model is reestimated dropping the second autoregressive term (a_1 assumed to equal zero), the response becomes stable. The revised model implies a *negative* long-run impact for the earlier period (−.62), that is, an initial rise in money leads ultimately to a fall in its level. For the second period, the long-run impact calculated from the revised model is 13.2; however, the fit compared with the original model is substantially worse in this case.

terval may encompass many quarters, depending upon the parameters of the above relation.

Table 2 summarizes the results of these estimations of relation (4): the first column lists the ultimate impact of an (unanticipated) increase of one percent in current money upon future money, while the second and third columns give measures of the significance and goodness of fit of the time-series models. In addition, Appendix Table A.1 gives the estimated impact of this increase upon the expected level of the money stock after four, eight, twelve, and sixteen quarters. Again note that the horizon over which permanent money is calculated is unknown and may vary across countries, so that the ultimate impacts listed in Table 2 are only approximations of their perceived impacts upon permanent money as defined earlier.[28] Also, the magnitudes of the estimates are often quite sensitive to the precise specification of the relation between current and past money growth used to estimate the long-run impacts. For both these reasons, our results are most meaningful for what they indicate about the relative persistence of money changes for a given country over the two time periods. Conclusions based upon the absolute magnitudes of the impacts, and to a lesser extent cross-country comparisons, are probably less meaningful.

In view of our earlier hypotheses, the results reported here are at best very mixed. For most countries, the long-run impact of a change in current money upon the level of future money increased between the earlier and later periods. The increase was quite sharp for Belgium, Germany, Italy, Japan, and the U.S.—countries which also showed an increase for the measured impact of money upon prices. However, the current money-future money impacts actually fell for France and Switzerland, although they showed an increase for the long-run effect of money on prices. Canada's results also were not consistent, and indeed those for the first period were dynamically unstable; see note 4 to Table 2. (With a slightly modified version of the Canadian model, the long-run impact for the first period was negative, implying that an initial rise in money leads ultimately to a fall in its level, while the impact was positive and well above unity in the second period.) Again, some of our results seemed implausible. For example, the long-run impact reported for the U.S. in Table 2 was below that found for most foreign nations, while the Table 1 results would suggest that the opposite pattern should hold, at least for the earlier period. The lack of clear-cut results perhaps should not be surprising, since stringent conditions would have to apply if the results of the money-inflation relation and current money-future money relation were to correspond. One plausible explanation may be that individuals use variables other than the money supply itself to forecast future money. In any event, the results suggest that either the theory developed earlier is over-simplified,[29] or at least that the monetary authorities' reactions to other economic variables must be accounted for explicitly, both in modeling individuals' forecasts of permanent money and in estimating the money-inflation relation (1).

Taken as a whole, our results reveal more possibilities than answers. The fact that the measured impact of money on prices is generally not unity is more consistent with the hypothesis that expectations about permanent money affect the relation between inflation and current and past money growth, than it is with the mechanistic view that the relation is the same regardless of whatever policy is followed. Furthermore, these long-run impacts generally shift between fixed-and floating-rate periods—and shift in a fashion that is compatible with our arguments as well as with widely-held views about exchange-rate implications for national monetary policies. Finally, our arguments are consistent with the Keran-Zeldes finding that money's impact upon prices is generally above unity under a floating-rate regime. However, our actual measurements of the persistence of money changes do not accord very well with the theory outlined here. In view of the crudeness of these estimates, further development and testing of models relating money forecasts to prices seems warranted.

III. Summary and Conclusions

It has long been noted that most economic variables react to past as well as current conditions. Except in a few cases, the sources of these lags in economic behavior are not precisely known. Until fairly recently, most lags were regarded as mechanistically determined by institutional rigidities, adjustment costs, and other factors which supposedly do not vary with government policies. Empirical relations derived from past data were commonly used to simulate the effects of policy changes and to predict economic conditions under policy regimes very different from those prevailing during the sample period. However, relations that used to be regarded as stable have shifted, often dramatically, with the accelerating inflation of recent decades, and this shift has considerably complicated the task of prediction and policy analysis. Many analysts have concluded from this experience that expectations about future economic conditions, including monetary policies, crucially influence the lags in economic relations—and that these expectations become more quickly adapted to changing conditions than once was thought.

This paper has considered the lags in a crucial relation for forecasting and policy analysis—the relation between inflation and current and past money growth. We argue that the lag in money's effect upon prices can be substantially affected by individuals' expectations about future money growth. This implies that money-inflation forecasting relations will change, at least eventually, when government policy alters the relation between current and past money growth and future money growth. The estimates of the money-inflation relations for several industrial countries seem quite consistent with this conjecture. In particular, the long-run impact of money on prices appears to have shifted substantially between the fixed- and floating-rate periods, and in a plausible fashion given the nature of those regimes. Furthermore, those relations often do not show the characteristics that would be expected if they were invariant to government policies. In particular, the long-run impact of money on prices frequently does not equal unity, as would be expected if those relations were invariant to policy.

Finally, we argue that the relative impact on inflation of the (permanent versus transitory) components of money growth may be stable across policy regimes, or at least more stable than under the standard forecasting relation. In particular, we argue that prices will react more to permanent money changes than to transient changes. If true, this hypothesis provides at least a rough indication of how inflation-forecasting relations can be adapted to altered policies. Although the crude evidence cited here does not confirm this hypothesis, it could prove useful in further research as we learn more about the money-supply process and the expectations surrounding that process.

APPENDIX

This appendix sketches several approaches to price determination that lead to price-permanent money relations similar to those discussed in Section II. Implications of this relation for the forecasting of inflation are also developed. In the following—as in the text—p(t) refers to the log of the price level, e(t) to the log of aggregate demand, and m(t) to the log of money.

Three Simple Models

A. **Interest rates, inflation expectations, and prices**

Suppose that prices vary immediately and proportionately with aggregate demand as in,

$$p(t) = e(t) \qquad (1)$$

Assume as well that aggregate demand varies proportionately with the current money stock and the (short-term) nominal interest rate, as indeed is implied by the usual money-demand relation. Then,

$$e(t) = m(t) - ai(t)\ ,\ a > 0 \qquad (2)$$

where i(t) is the one-period interest rate. Finally suppose that i(t) is equal to a fixed real rate, taken here as zero, plus an inflation premium:

$$i(t) = {}_{t}p^{e}(t+1) - p(t) \qquad (3)$$

Now if bond-market participants are aware of the relations (1) and (2), their price expectations, and therefore interest rates, will be based upon their forecasts of future money. Substituting (1) into (2), that is,

$$p(t) = m(t) - a({}_{t}p^{e}(t+1) - p(t)) \qquad (4)$$

Taking the p(t) on the right over to the left and repeatedly substituting then gives,*

$$p(t) = \frac{1}{1+a} \sum_{j=0}^{\infty} \left(\frac{a}{1+a}\right)^{j} + {}_{t}m^{e}(t+j);\ \text{where } {}_{t}m^{e}(t) = m(t) \qquad (4)$$

Defining permanent money as the discounted value of present and future money in the above gives an infinite-horizon analog to the relation in the text. In arriving at this, rational expectations in its strictest sense need not be invoked: (4') will be valid regardless of how "rationally" future money is forecast. The relation (4') effectively reflects a "Fisher" interest-rate impact upon prices; the implications of this for inflation were described in detail in Cagan's classic article on hyperinflation.**

B. "Permanent" Money Demand

Suppose that (1) is valid but that now,

$$e(t) = \frac{1}{n}[m(t) + {}_{t}m^{e}(t+1) + \ldots {}_{t}m^{e}(t+n-1)] \qquad (2)$$

That is, current expenditure depends not only upon current money but upon an average of current and expected future money. Evidently p(t) then will respond proportionately to permanent money, as defined by the right-hand-side of the above expression.

C. Contracts and Pricing

A still simple but somewhat richer model of permanent money and prices is based upon contracts. Suppose in a given industry that prices are set for several periods, say i, at a time. Imagine also that the supply of output is given exogenously, so that the task of the price setter is essentially to forecast demand over the life of the contract.*** Assume finally that the value of industry sales in a given period is a fixed fraction of aggregate expenditure, which in turn varies proportionately with current money (i.e., e(t) = m(t)).

Now in each period, there will be a single price which will allow the firms in the industry to sell just the amount available, no more nor less; define this as the "desired" price, since if firms were not constrained by contract this would be the price they would actually set. It seems reasonable to suppose, then, that contract prices will be set at some average of expected "desired" prices over the life of the contract. Let p(t) now refer to the log of the industry price. Then since "desired" prices vary proportionately with money,

$$p_{i}(t) = \frac{1}{i}[m(t) + {}_{t}m^{e}(t+1) + \ldots {}_{t}m^{e}(t+i-1)] \equiv m^{*}(t) \qquad (5)$$

where the price is newly set at the beginning of period t (and fixed through the next i-1 periods), and where we assume m(t) is known at that point (this is not essential). The money forecasts might also be discounted.****

In relating aggregate prices to money, we must take account of the fact that contracts are likely to be staggered (i.e. expire at different times) and to be of different lengths. Suppose first that all contracts are of the same length but are staggered evenly in the following manner: in each period, industries whose contracts are being renegotiated account for the same fraction (1/i) of aggregate expenditure. Defining the aggregate price index (in logs) as a simple average of industry prices then gives,

$$p(t) = \frac{1}{i}[m^*(t-i+1) + m^*(t-i+2) + \ldots m^*(t)] \quad (6)$$

Here the first term represents prices set in the oldest non-expired contract. Thus, in contrast to the earlier models, the contract model allows for a lag between prices and permanent money—as we will see below, a lag between prices and actual money will be observed even if this is not the case. This offers a potential explanation of the Keran-Zeldes finding of an apparently shorter lag between money and exchange rates than between money and prices. Exchange rates are apt to respond immediately to permanent money—i.e., transient money changes will tend to be speculated out—while the price response can be delayed because of contracts.

Finally, the existence of different contract lengths does not greatly alter conclusions based upon (6). To each contract length there corresponds a particular horizon for the calculation of permanent money. When there are different contract lengths, the current aggregate price level will be a weighted average of current and past values of these alternative permanent-money aggregates.

Implications of Models

When prices depend upon forecasts of future money, as in the above, the usual forecasting relation between p(t) and current and past m() depends upon how individuals use current information to predict money. To see this, suppose that the price-permanent money relation is as shown in (6). Assume first that money follows a (invertable) stationary process—known to individuals and used by them to forecast—described by,

$$A(L)m(t) = u(t)\ ,\ A(L) \equiv 1 + a_1L + a_2L^2 + \ldots \quad (7)$$

where u(t) is a white-noise disturbance and A(L) is a polynomial in the lag operator L. To simplify matters, suppose that the horizon over which permanent money is forecast is two periods (i = 2). If individuals use only the past history of money in forecasting its future—that is, if they employ (7)—permanent money can be written as,

$$m^*(t) = \tfrac{1}{2}[(1-a_1)m(t) - a_2m(t-1) - a_3m(t-2) + \ldots] \quad (8)$$

since $m(t+1) = u(t+1) - a_1m(t) - a_2m(t-1)\ldots$, so ${}_tm^e(t+1) = -a_1m(t) - a_2m(t-1)\ldots$. Then substituting in (6)

$$p(t) = \tfrac{1}{2}[m^*(t) + m^*(t-1)] = \tfrac{1}{4}[(1-a_1)m(t) + (1-a_1-a_2)m(t-1) - (a_2+a_3)m(t-2)+\ldots] \quad (9)$$

Relation (9) is the standard relation of prices and current and past money given in the text. Notice that the long-run impact of money on prices measured from this—which is $\tfrac{1}{2}(1-a_1-a_2\ldots)$—depends upon the coefficients of the process (7) generating money, and generally will not be equal to unity.

To see this more specifically, suppose first that money is known and expected to follow a given path with random but temporary deviations:

$$m(t) = \bar{m} + u(t) \quad (10\text{-a})$$

where u(t) is a white noise. In effect the authorities are expected to correct any "base-drift" in the next period, since ${}_tm^e(t+1) = \bar{m}$. Then the price-money relation is,

$$p(t) = \bar{m} + \tfrac{1}{4}[(m(t) - \bar{m}) + (m(t-1) - \bar{m})] \quad (11\text{-a})$$

so that the long-run impact of money upon prices is ½; this will be smaller of course for longer forecasting horizons. In contrast, suppose that money changes are purely random, that is "base-drift" is not corrected,

$$m(t) = m(t-1) + u(t) \quad (10\text{-b})$$

Then at any time the forecast of future money is simply today's observed level: thus $m^*(t) = m(t)$ and,

$$p(t) = \tfrac{1}{2}(m(t) + m(t-1)). \quad (11\text{-b})$$

The long-run effect here is unity. It is easy to show that when current money changes are expected to be reinforced in the future, this long-run impact can be greater than unity. Hence the more persistent that money changes are expected to be, generally the larger will be the apparent long-run impact of money on prices measured from money-inflation forecasting relations.

More generally, future money may be predicted from information other than its past; letting z(t) stand for such additional information (which will usually include past data), we might then have,

$$m^*(t) = B(L)m(t) + z(t). \quad (12)$$

Plainly, the relation used to forecast prices then must include z(t). Conversely, the fact that non-monetary variables are useful in "explaining" or predicting inflation in standard relations does not necessarily mean that they can directly affect prices, independently of money.

To summarize the implications of this view, when prices respond to permanent money as defined here:

i) The long-run impact of money on prices measured from inflation-forecasting equations will depend upon how future money is forecasted, and generally will not be unity.

ii) When current money changes are typically viewed as transient, the long-run impact of money on prices will generally be less than unity, and less than when such changes are expected to be permanent or reinforced.

iii) Inflation-forecasting equations should include all variables used to forecast future money, and not simply current and past money. As these indicate, it generally will not be possible to test propositions about the causal links between money and prices using only the empirical relation between prices and current and past money; the same point was made in a slightly different context by Lucas (1970).

Table A.1
Impact of a One-percent Increase in Current Money Growth on the Expected Future Level of the Money Stock*

	1957–1969 Percent Increase in Money Stock Level Expected After:				1970–1979 Percent Increase in Money Stock Level Expected After:			
Country	**4 Qtrs**	**8 Qtrs**	**12 Qtrs**	**16 Qtrs**	**4 Qtrs**	**8 Qtrs**	**12 Qtrs**	**16 Qtrs**
Belgium	.22	.56	.58	.58	2.32	4.79	5.90	6.41
Canada[1]	.40	.35	.33	.30	3.53	8.06	11.62	14.47
France	2.23	4.30	5.60	6.44	2.47	3.33	3.32	3.32
Germany	.85	1.46	1.70	1.80	2.54	3.30	3.30	3.30
Italy	.34	1.16	1.22	1.22	.81	2.09	2.31	2.36
Japan[2]	.26	1.10	1.01	.99	3.10	7.22	9.83	11.53
Netherlands	.62	1.23	1.23	1.23	1.50	2.81	3.09	3.16
Switzerland	2.38	4.02	4.73	5.07	5.41	5.13	4.94	4.97
U.K.	.88	1.48	1.48	1.48	4.16	1.97	2.60	2.43
U.S.[3]	.27	2.26	−1.53	.28	2.03	2.77	2.78	2.78

*Results are based upon a simulation of the estimates summarized in Table II in the text.
[1]The results for Canada for the first period are unstable in that the *absolute value* of money changes (although not their cumulative sum) increases over time. When the model is reestimated suppressing the second autoregressive term, the long-run impact for the first period is negative and virtually complete after six quarters.
[2]The Japan results for the first period show considerable "cycling" in the first four quarters; after two quarters the expected money stock level is up 1.8%, while it is up only .55% after five quarters.
[3]The U.S. results for the first period again show substantial "cycling."

1. The "long and variable lag" for nominal income and money was first documented for the U.S. by Milton Friedman, in "The Lag in the Effect of Monetary Policy," in his **The Optimum Quantity of Money and Other Essays.** See also the article on "Inflation and Monetary Accommodation in the Pacific Basin" by Michael Bazdarich in the Summer 1978 issue of this **Economic Review,** as well as the article by Michael Keran and Stephen Zeldes in this issue.

2. See, for example Gordon (1976), pp. 201–02.

3. The conditions for money neutrality are fairly stringent. First, transfers of wealth among individuals resulting from price-level changes must not affect **aggregate** demand and supplies. Second, open-market exchanges of money for government bonds will not be neutral **unless** individuals discount future tax liabilities in calculating their wealth, so that for the "typical" individual, government bonds are not net wealth. Furthermore, the proposition does **not** apply to money-supply changes accompanied by variations in real government expenditure or taxes. Finally, money neutrality refers to changes in the level of money with its long-run growth rate held constant; if anything, there is a consensus that changes in the long-run money-growth rate are not neutral.

4. Specifically, most economists would now agree that money changes have negligible **long-run** impacts on real output and unemployment, that is, the "Phillips" curve is vertical in the long-run. This factor, combined with empirical estimates of money-demand relations (where real balances are generally a function of real output and interest rates) suggests that a rise in money (with no change in its expected growth rate) will raise the price level proportionally.

5. Trends in real output and velocity enter because they influence the real demand for money. This real demand can be permanently affected by factors, such as financial innovations, that are not easily summarized quantitatively—and indeed are not always observable, and thus cannot be accounted for explicitly. Since these factors then enter the disturbance term in the empirical relation, the relation (1') relating price and money **changes** is most often used; these factors would cause the constant term relating the level of prices and money to shift about during the sample period. Consequently, this relation is less practical as a form for estimation. For this reason, the empirical results referred to later will be of the second form, and we will normally refer to the money-growth inflation relation in the text.

6. In other words, we can imagine a system where prices, output, and interest rates are simultaneously determined as, for example,

$$\begin{pmatrix} \Delta p(t) \\ \Delta q(t) \\ i(t) \end{pmatrix} = A \begin{pmatrix} \Delta p(t) \\ \Delta q(t) \\ i(t) \end{pmatrix} + C\Delta m(t)$$

where i(t) is the interest rate, A is a matrix of lag polynomials, and C is a vector of such polynomials. The lagged relation between money and prices referred to in the text is defined as the "reduced form" solution of this system where prices depend only upon money: This is obtained by solving the above system to obtain an equation relating price and money changes only. This is the text relation (1) and it includes all indirect effects upon prices of output and interest rate responses to money. This fact makes it often difficult to interpret the empirical counterparts of (1).

7. See Rutledge (1979) and (1977) for a more detailed discussion.

8. This is the rationale implicit in Barro (1979).

9. Indeed, nearly all rational-expectations models imply that economic decisions depend upon expectations of future policy variables. Some concrete illustrations of this are described in the Appendix.

10. Arthur Okun ("Inflation; its Mechanics and Welfare Costs," **Brookings Papers on Economic Activity:2, 1975)** discusses the reasons why price fluctuations may be limited by tacit agreement in what he describes as "customer markets." See especially pp. 358-73.

11. That is, decisions about inventory levels, work schedules, etc., are all likely to depend upon firm anticipations of "typical" patterns of behavior of variables affecting firm costs and profits.

12. This is, of course, implied by the hypothesis of "rational expectations"—but it is more general. Individuals may not make use of all information potentially available, but they are likely to adapt whatever forecasting techniques they do use to changed policies, at least given enough time.

13. This observation is relevant to tests of the influence of, (say) government deficits on prices. Suppose that the deficit is found to be a significant variable, in addition to current and past money, in a regression "explaining" inflation. Does this imply that the deficit affects inflation **independently** of money growth? The arguments in the text suggest that this is not necessarily the case if the monetary authorities react to deficits so that deficits provide a "signal" of future money growth. As will become clearer in the next section, tests about the causes of inflation cannot generally be based upon relations such as (1) alone. This point has been emphasized by Lucas (1970).

14. In Britain, for example, the authorities define monetary objectives for M-3, while in Japan targets are set for M-2. See the OECD's **Monetary Targets and Inflation** (p. 27) for an assessment of the stability of money-demand relations using alternative aggregates. This finds M-2 inferior to M-1 for Germany, while M-2 is at best marginally "preferable" to M-1 for Japan. The choice also does not seem clear-cut in the U.K.; see also Goodhart and Crockett (1970).

15. Another reason for including this dummy variable is the possible shift in the perceived long-run growth rate of money—that is its unconditional mean—in several countries. If so, the models developed in the Appendix also imply a shift in the constant term in a regression of price changes on current and past money growth. This change does **not** necessarily arise from the resulting change in interest rates (although it may, at least in part). For example, in the simple contracting model in the Appendix, there is no interest rate impact on prices. However, a rise in the long-run money-growth rate will lead to an increase in the "shift" parameter used by rational forecasters to predict permanent money,

and this "shift" parameter is included in the constant of a standard inflation money growth relation.

The real balance correction (similar to the one used by Keran and Zeldes for their article in this **Review)** is taken over 12 quarters, in order to 'smooth out' any business-cycle fluctuations in the real demand for money that might be induced by variations in nominal money growth. Basically, this correction is designed to adjust for shifts in real money demand that are unrelated to actual nominal money changes but which tend to add 'noise' to the money-inflation regression. An example of such a shift would be changes in the real demand for various currencies as a result of the switch from fixed to flexible rates, or changes due to financial innovations that influence velocity. It should be noted that this correction often affects the results substantially. Frequently, the inclusion of this term substantially reduces the regression standard error for the second period. Moreover, the correction often substantially raises the estimate of money's long-run impact upon prices for the second period. Finally, in three cases the comparisons of the long-run impacts between the two periods are affected by the correction: for Canada, the long-run impact declines from the first to the second period when the correction is not included, although again the change is fairly small and both impacts remain well below unity; and for both Germany and the Netherlands, the long-run impacts are negative in the second period when the correction is not included (for Germany, the dummy variable also substantially affects the results). The results obtained by omitting the real money-demand correction and dummy variable will be supplied upon request.

16. For example, suppose that an acceleration in money growth is associated not only with an expectation of higher future inflation but also with an increased risk of holding that money. This increased risk may then reduce the real demand for money in a way not captured by the interest rate (i.e. it induces a shift in the real money-demand function).

17. Michael Darby ("Sterilization and Monetary Control under Pegged Exchange Rates: Theory and Evidence," NBER Working Paper #449, February 1980) also finds that foreign countries had very considerable short-run control over their domestic money stocks during the adjustable-peg regime. This suggests a general lack of bias in the Table I results resulting from "feedback" from prices to money operating via reserve flows. It is important to note that this argument refers to the short-run; in the long-run, foreign money stocks probably would have had to conform to the trend in U.S. money. Rudimentary tests for a causal relation from prices to money were also run for the two periods. Some feedback from prices to money was detected for Japan and the U.K., and possibly Germany, for the earlier period. Interestingly, there was some evidence of a feedback for Italy and Japan for the later period. These results will also be supplied upon request.

18. This, admittedly, is something of an oversimplification, in that firms will also have to estimate costs over the contract period in setting prices. The simple model in the Appendix assumes that firm supply is essentially exogenous and fixed, so that the firm's task is to estimate future demand only. Taylor (1980) considers a more complex model in which wages and price setting "interact," but one which yields similar results to those developed here. In still more complex models, decisions regarding prices, investment, inventory, and output are all interdependent. In these cases, the dependence of prices on expected future money is not likely to be as simple as the relation described in the Appendix.

19. This horizon need not, of course, be the same for all agents. As indicated in the Appendix, when prices are set by contracts, the horizon for permanent-money calculations may depend upon the contract length. This horizon may also be infinite, as in the case where aggregate demand depends upon interest rates. Finally, the calculation of permanent money might involve discounting of expected future m( ).

20. In particular, output responses to money and their effects upon aggregate demand are ignored. Taylor (1980) considers wage-price interactions.

21. See the Appendix for further details. Contracts provide one possible explanation for the Keran-Zeldes finding (in their article in this **Review)** that the lag between money and exchange rates is shorter than that between money and prices. Specifically, exchange rates are free to adjust immediately to permanent money changes, while price responses may be delayed by contracts.

22. See the Appendix for further details. It should be noted that this does **not** require that interest rates significantly affect aggregate demand. Bilson (1978) has noted that the long-run effect of money on exchange rates will depend upon the characteristics of the money-supply process.

23. Lucas' (1970) statement applies here: ". . .the natural rate hypothesis restricts the relationship of policy parameters to behavioral parameters. It cannot be tested on a behavioral relationship (Phillips curve, supply function, and so on) alone." (p. 57) Indeed, this is an elegant and succinct statement of the basic arguments in the text about the money-inflation relation. But there is also wide acceptance of the opposing view—see for example Gittings (1979)—that causal restrictions should be imposed on money-inflation relations.

24. Evidence that money has "accommodated" domestic variables, such as government deficits and wage increases, can be found in Gordon (1977).

25. See Logue and Sweeney (1978), pp. 153–55.

26. In practice, countries may have occasionally varied money growth so as to limit exchange-rate fluctuations. Something like this occurred in 1978, when large intervention in support of the dollar was partly responsible for substantial overshooting of money-growth targets in Germany and Switzerland. There is also evidence for Japan (see my "Rational Expectations and Countercyclical Monetary Policy: The Japanese Experience" in the Summer 1978 issue of this **Review**) that the monetary authorities reacted to Japanese-U.S. price shifts after 1971. In short, money abroad may still be somewhat constrained by exchange-rate considerations, so that the current floating-rate regime differs only in degree from the former fixed-rate regime.

27. The model included moving-average terms at lags one, two, and four (see the notes to Table II) as well as two autoregressive parameters at lags one and two. The third lag was omitted, as it generally was not statistically significant. The long-run effects reported in the table are of-

ten quite sensitive to variations in the number of moving-average or autoregressive terms; for this reason they should be interpreted with considerable caution.

28. As indicated in the Appendix (see Section II), the measured long-run impact of money on prices will generally vary with the horizon over which permanent money is forecasted. Indeed, in the first example given there, an increase in current money has no effect upon the long-run money stock—but the long-run effect of money on prices as measured from the standard relation is positive, although below unity.

29. Two possibly significant effects that I have largely ignored are the influence of unanticipated money changes and the interaction of output adjustments and price changes. In the rational-expectations model of Barro (1979) and others, prices are supposed to react immediately and proportionately to money changes that are expected (perceived). Unanticipated changes, however, push real output away from its "natural" rate, and hence influence aggregate demand. In this case, prices will react not only to forecasts of future money but also to past errors in predicting money. This is likely to lead to price-money relations that are more complex than implied by the hypothesis developed in the text.

APPENDIX FOOTNOTES

*This is not the only technically admissable solution, although it is economically the most sensible.

**Phillip Cagan, "The Monetary Dynamics of Hyperinflation," in Milton Friedman (editor) Studies in the Quantity Theory of Money, pp. 25–117.

***Thus the influence of fluctuations in wages and other costs on output supply is ignored. Taylor ( ) considers pricing based upon both wage and demand projections, but the implications of his model are very similar to those considered here.

****For example suppose that there is a loss from deviations from the desired price that is proportional to the difference of (the logs of) the actual and desired price. Then the firm is apt to seek to minimize the discounted value of such losses, which would lead to discounting of money forecasts in the calculation of m*( ).

REFERENCES

Barro, Robert. "Unanticipated Money, Output, and the Price Level in the United States," **Journal of Political Economy,** Volume 86, No. 4, pp. 549–580.

Bilson, John F. "Rational Expectations and the Exchange Rate," in Jacob Frankel and Harry G. Johnson (eds.), **The Economics of Exchange Rates,** (1978), pp. 78–80.

Darby, Michael R. "Sterilization and Monetary Control Under Pegged Exchange Rates: Theory and Evidence," **NBER Working Paper No. 449,** February 1980.

Gittings, Thomas A. "A Linear Model of the Long-Run Neutrality of Money," Staff Memorandum 79–6 of the Federal Reserve Bank of Chicago.

Goodhart, Charles A.E. and Crockett, Andrew. "The Importance of Money," **Bank of England Quarterly Review,** Volume 11, No. 2 (June 1970), pp. 159–198.

Gordon, Robert J. "Recent Developments in the Theory of Inflation and Unemployment," **Journal of Monetary Economics,** Volume 2 (1976), pp. 205–210.

———. "World Inflation and Monetary Accommodation in Eight Industrial Countries," **Brookings Papers,** No. 2/1977, pp. 409–468.

Logue, Dennis E. and Sweeney, Richard J. "Aspects of International Finance," **Journal of Financial and Quantitative Analysis,** March 1978, pp. 143–156.

Lucas, Robert E. Jr. "Econometric Testing of the Natural Rate Hypothesis," in Otto Eckstein (ed.), **The Econometrics of Price Determination,** Proceedings of a Conference sponsored by the Board of Governors of the Federal Reserve System and the Social Science Research Council, October 30–31, 1970.

Rutledge, John. "A Neoclassical Model of Wage and Price Dynamics," **Proceedings of the West Coast-Academic Federal Reserve Economic Research Seminar,** Federal Reserve Bank of San Francisco, November 1977.

———. "The Effect of Money on Output and Prices," **Proceedings of the West Coast Academic/Federal Reserve Economic Research Seminar,** Federal Reserve Bank of San Francisco, November 1979.

Taylor, John B. "Aggregate Dynamics and Staggered Contracts," **Journal of Political Economy,** Volume 88, No. 1 (February 1980), pp. 1–23.