FEDERAL RESERVE BANK
OF SAN FRANCISCO

ECONOMIC REVIEW

ASPECTS OF INFLATION

SPRING 1980

The Federal Reserve Bank of San Francisco's **Economic Review** is published quarterly by the Bank's Research and Public Information Department under the supervision of Michael W. Keran, Senior Vice President. The publication is edited by William Burke, with the assistance of Karen Rusk (editorial) and William Rosenthal (graphics). Opinions expressed in the **Economic Review** do not necessarily reflect the views of the management of the Federal Reserve Bank of San Francisco, nor of the Board of Governors of the Federal Reserve System.

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Aspects of Inflation

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Aspects of Inflation

Inflation has become perhaps the most serious problem affecting the industrial world over the past decade or more, and thus it has also become the most important topic of research for the world's economists. For example, roughly half of all the issues of the *Economic Review* during the past half-decade have concerned various aspects of the inflation problem. This issue contains several articles on the subject, as the search continues for viable solutions to this severe and long-continuing problem. These articles explore such questions as the relationship between monetary disturbances and exchange rates, the factors determining the lagged relation between money and prices, and the influence of cost-push and government-spending pressures on money-supply growth and inflation.

Michael Keran and Stephen Zeldes, in the first article, investigate the link which exists between money and exchange rates through the goods and asset markets. Most analysts agree that the fundamental influence on the exchange rate is the need to maintain "purchasing power parity"—the parity of national price levels between countries. Because national price levels change slowly over time, it could be assumed that exchange rates also would change slowly over time. But exchange rates have shown much greater variance than underlying price levels since 1973, so that analysts have come to question the validity of the purchasing-power-parity approach to exchange-rate determination.

Keran and Zeldes therefore find it necessary to develop an alternative model to explain short-run exchange-rate movements—one which links monetary disturbances to short-run adjustments in the bond market. In their analysis, they argue that the exchange rate in the long run is determined solely by purchasing-power-parity considerations, while long-run interest-rate differentials across countries reflect differences in inflation expectations. In contrast, short-run exchange-rate movements depend on assumptions about 1) adjustments of various markets and 2) expectations concerning the path of future money growth.

To test their model, Keran and Zeldes utilize four sets of equations which compare the U.S. bilaterally with five other major countries. On the basis of those tests, they conclude that the inflation differential is significantly affected, with long lags, by the growth in the "excess" money supply in the U.S. relative to each of the other countries—and that the exchange rate is similarly affected, although with much shorter lags. They find also that long-term interest-rate differentials are significantly related to the relationship between U.S. and foreign excess-money growth rates. On the other hand, short-term interest rates are influenced by both a liquidity effect and an inflation-expectation effect of a change in excess money.

Charles Pigott, in a second article, examines the lag between money and prices, and the way that that lag is affected by expectations about monetary policy. Until fairly recently, most lags in economic behavior 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 also to predict economic conditions under policy regimes very different from those prevailing in the sample period. But as Pigott notes, with the accelerating inflation of recent decades, relations that used to be regarded as stable have shifted, often dramatically.

Consequently, he concludes 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. In his analysis, he considers the lags in a relation which is crucial for forecasting and policy analysis—the relation between inflation and current and past money growth.

Pigott argues 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—as he finds in measuring the experience of several industrial countries. In fact, the long-run impact of money on prices implied by this relation appears to have shifted substantially between the fixed rate period of the 1960's and the floating-rate period of the 1970's. Further, he argues that prices will react more to money changes perceived as permanent than to transient changes. If true, this could provide at least a rough indication of how inflation-forecasting relations can be adapted to altered policies.

Michael Bazdarich, in a final paper, examines the causality of U.S. inflation over the past two decades. Most economists, in his view, would agree that nonmonetary factors can have a sustained effect on the inflation rate only if they are accommodated or "validated" by increases in the money supply. Thus, the debate on the causes of inflation and the proper anti-inflation policy revolves around the issue: what factors have typically caused movements in the rate of money-supply growth?

Bazdarich develops his argument by conducting tests of cost-push and government-spending theories of inflation. According to the cost-push approach, central banks are forced to expand money and credit in response to large cost increases in various industries, in order to avoid the output losses and unemployment that would normally follow such phenomena. According to the government-spending argument, central banks must monetize large government deficits in order to avoid such alternative financing approaches as tax increases or government-debt issues (with rising interest rates). Bazdarich applies the Granger causality-test technique to determine whether these several "causes" of inflation have systematically caused, or been caused by, money-supply growth. The results provide evidence regarding the causal relationship between the individual variables and recent U.S. inflation.

Bazdarich tested seventeen indicators of cost-push or "supply shock" pressures with respect to four measures of the money supply, but found virtually no evidence of monetary accommodation. In the vast majority of cases, the results indicate "one-way causality" from several or all of the money-supply measures to the respective price or cost indicator. The results were less conclusive for government spending or deficit measures. But although some of the latter indicators displayed causal effects on the money supply, the results were either unsatisfactory in some way or were subject to conceptual problems involving the forms of the equations. Additionally, in examining the 1974-75 and 1978-79 inflationary episodes, he found that previous and/or concurrent money-supply growth provided a reasonable explanation of most of the inflation in each case.

Effects of Monetary Disturbances on Exchange Rates, Inflation and Interest Rates

Michael Keran and Stephen Zeldes*

It has long been recognized that inflation is primarily a monetary phenomenon. However, some important implications of that relationship have become widely recognized only in recent years. We now realize, for example, that the link between the quantity of money and the price of goods also has implications for the value of financial assets—and further, that the effects of monetary disturbances on the prices of goods and assets have implications for international currency values in the foreign-exchange market.

The purpose of this article is to shed additional light on the relationship between a monetary disturbance and exchange rates by investigating the link through the goods and asset markets. Most analysts agree that the fundamental influence on the exchange rate is the need to maintain "purchasing power parity"—that is, parity of national price levels between countries. Because these national price levels change slowly over time, it had been assumed that the exchange rate would also change slowly over time. This has not occurred; since the move to flexible exchange rates in 1973, exchange rates have showed much greater variance than the underlying price changes.

This phenomenon has called into question the validity of the purchasing-power-parity approach to exchange-rate determination, at least in the short run. Analysts thus have developed a series of alternative models to explain short-run exchange-rate movements on the basis of factors other than purchasing power parity.[1]

This article presents one such model—one which links monetary disturbances to short-run adjustments in the bond market. In Section I, we present the long-run equilibrium effects of a monetary disturbance on inflation rates, interest rates, and exchange rates. We note there that the exchange rate in the long run is determined solely by purchasing-power-parity considerations, while long-run interest-rate differentials across countries reflect differences in inflation expectations. In Section II, we concentrate on short-run movements in the system. In this section, we question the standard assumption of continuous money-market equilibrium, and demonstrate that short-term exchange-rate movements depend on the short-run response of interest rates to a monetary disturbance. For example, a monetary disturbance can affect interest rates in two opposite ways, because it can have both a liquidity effect and an inflation-expectations effect. The adjustment path of the exchange rate toward long-run purchasing-power parity will depend on the relative magnitude of those two opposing influences. We note that profit opportunities in the bond market can induce short-term capital flows, which cause the exchange rate to move more than it would under conditions of short-run purchasing-power parity.

Section III translates the propositions of Sections I and II into testable hypotheses, and Section IV presents the evidence which tests

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these theoretical conjectures. To test the model, we utilize 4 sets of equations, each of which compares the U.S. bilaterally with five other major countries. The results suggest that in four of those countries (Germany, Italy, Japan, and Switzerland), the exchange rate changes more rapidly than the ratio of national price levels in response to a monetary disturbance, while in the fifth country (France), the adjustments occur at about the same speed. The results also suggest that for only one country (Switzerland), the exchange rate tends temporarily to overshoot its long-run value (the value consistent with long-run purchasing-power parity) following a monetary disturbance.

I. Theoretical Framework (Long Run)

The monetary approach to exchange-rate determination provides a conceptual basis for simultaneously analyzing the interactions among the major markets of the economy. We can begin with the determination of the long-run equilibrium price level. (All variables, except interest rates, are to be interpreted in log form.)

Home-country price level:

$$P = M - m^d \equiv ME \qquad (1)$$

Foreign-country price level:

$$P^* = M^* - m^{d*} \equiv ME^* \qquad (2)$$

where:

*denotes foreign country
P = log of price level
M = log of nominal money supply
m^d = log of real money demand (assumed to depend on the nominal interest rate and real permanent income)
ME = log of "excess money" (defined as the difference between the log of *nominal* money supply and the log of *real* money demand)

Equations 1 and 2 specify that, in the long run, the price level in each country is equal to that country's excess supply of money. These equations are based on the notion of long-run equality between real money supply and real money demand. They tell us that a rise in the level of the nominal money supply will, given constant real money demand, be matched by a proportional rise in the price level.

We assume here that only the domestic central bank can supply money and that only residents of a country will demand money denominated in that currency. This money-demand assumption is based on the unique role of the national money stock as a means of payment. One cannot purchase goods in one country with the currency of another country. There is a strong preferred habitat in the demand for money which is not necessarily observed in the demand for goods or non-money assets. An excess supply of money in one country cannot be used directly to satisfy the excess demand for money in another country, i.e. there is no currency substitution.[2] However, an increase in excess money in one country will induce an excess demand for goods and financial assets in that country which, in turn, can affect the goods and assets markets in another country. The exchange rate acts as a conduit to link the goods and asset markets of the two separate countries.

The next step in the analysis involves the formation of inflation expectations. We assume that price expectations are formed rationally. The rational-expectations view of market behavior says that market participants form forecasts of future events based on the relevant economic model and all available information. We can therefore use price equations 1 and 2 to generate the following price-expectation equations:

$$p^e = ME^e \qquad (3)$$

or in change form

$$\Delta p^e = \Delta ME^e \qquad (4)$$

where 3) and 4) are long-run equilibrium conditions which hold for each country. Superscript e denotes expectations, and ΔP and ΔME

refer to the first differences of logs of the price level and excess money, respectively. Equation 3 says that if excess money determines the actual price level, then expected excess money will determine the expected price level. Similarly, current long-run inflation expectations in each country are determined by long-run expected excess-money growth.

Our next equations deal with the determination of the long-term nominal interest rate. We assume that the real interest rate—that is, the nominal rate minus the expected inflation rate—in the long run will be independent of monetary factors. This assumption is based on the presumed existence of "real assets", whose nominal yields automatically adjust by the same amount as the inflation rate. The inflation-adjusted yield on these "real assets" is therefore determined solely by technological factors, which are presumably independent of monetary factors. Because of the possibility of substitution over the long run between financial assets and these real assets, nominal rates on financial assets also will fully incorporate any change in long-run inflation expectations. Combining this concept with equation 4, we arrive at the following equation:

$$R = \Delta P^e + r = \Delta ME^e + r \qquad (5)$$

where:

R = long-term market interest rate
ΔP^e = expected long-run inflation rate
ΔME^e = expected excess money-growth rate
r = real interest rate.

Our next equations explain the equilibrium exchange rate. Equation 6 expresses the purchasing-power-parity (PPP) condition which equates the exchange rate (S) to the difference of the log of the price levels in each country (P*-P), adjusted for terms of trade (T).[3]

$$S = P^* - P + T = ME^* - ME + T \qquad (6)$$

and

$$\Delta S^e = \Delta P^{*e} - \Delta P^e = \Delta ME^{*e} - \Delta ME^e \qquad (7)$$

Equation 7 assumes that expected changes in terms of trade (ΔT^e) are zero. As these changes generally take the form of real shocks, it seems reasonable to assume that expected changes over time are zero. Equation 6 tells us that the equilibrium bilateral exchange rate is a function of the ratio of excess money supplies of the two countries. Equation 7 tells us that the long-run expected change in the exchange rate depends on the long-run expected growth in the excess money supply of each country.

Because of the possibility of substitution between real assets of different countries and because of long run PPP, we can also assume that over the long run, real interest-rate parity will hold:[4]

$$r = r^* \qquad (8)$$

From equations 5 through 8 we can derive the nominal interest-rate parity condition:[5]

$$R = R^* - \Delta S^e \qquad (9)$$

This equation tells us that the domestic nominal interest rate should be equal to the foreign nominal interest rate minus the expected annual rate of appreciation of the domestic currency over the term of the asset.

All of these equilibrium relationships can be expected to hold over the long run, with certain short-run deviations. Also, all of the equations are valid under both fixed- and flexible-rate regimes, although with different directions of causality under the two structures.[6] In this paper we deal only with adjustments under a flexible-rate regime. The general equilibrium nature of the model can best be illustrated by an analysis of the long-run effects of some monetary disturbances, which then provides a point of reference for an analysis of short-run adjustments.

Consider first the long-run effects of a one-time contemporaneous increase in the level of a country's money stock, with no change in its expected future growth. The resulting increase in the supply of money relative to the demand for money will be matched by an equal excess demand for the sum of goods and non-monetary assets. Equilibrium will be restored in this case via a price adjustment, i.e. a rise in the domestic price level and a depreciation of the exchange rate. Equations 1 and 2 determine the home and foreign price levels, and equation 3 determines the exchange rate. The neutrality of money and PPP conditions requires that the changes in the price level and the exchange rate be proportional to the initial increase in the money stock. The rise in the price level will reduce the real money supply to its initial level, restoring equilibrium in the money market, and the depreciation of the exchange rate will maintain the purchasing-power-parity condition. Interest rates will not be affected by this one-time change in money, because there will be no change in its expected future growth rate, and thus no change in inflation expectations.

Next consider the long-run effects under a flexible-rate regime of a second type of monetary disturbance—a permanent increase in the growth rate of the domestic money supply. Again, equilibrium will be restored via a price adjustment. An expected higher money growth rate leads to a higher expected inflation rate, which means a comparable increase in the long-term interest rate; the interest-rate differential between two countries will therefore just equal the expected inflation differential. In a steady-state condition, the money supply, the price level, and the exchange rate will all change at the same rate (equal to the expected rate), and the level of the long-term interest rate will be permanently higher. There will be no incentive to switch between securities of different countries, because higher domestic interest rates will fully compensate holders of domestic financial assets for the expected depreciation of the currency.

The usefulness of the long-run model depends on one key empirical regularity—purchasing-power-parity, or the equality between bilateral exchange rates and the ratio of national price levels. In the long run, a close association of this type has been apparent for the United States with respect to five other countries: France, Germany, Italy, Japan, and Switzerland (Chart 1). However, for reasons discussed in the next section the relationship is not particularly close in the short run.[7]

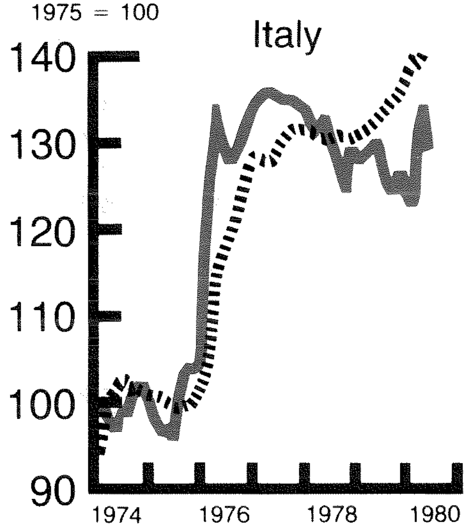
II. Theoretical Framework (Short Run Adjustments)

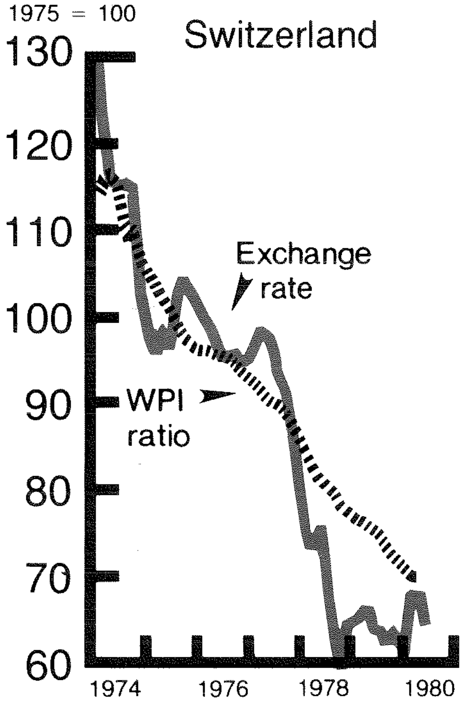
Our analysis of the nature of the long-run equilibrium does not describe the mechanism by which equilibrium is achieved, nor does it describe the movements of the economic variables between equilibria. The short-run movements of the system depend on assumptions about the nature of the adjustment process in different markets. As seen below, real interest-rate parity (equation 8) need not hold in the short run, but nominal interest-rate parity (equation 9) is a short-run condition which must hold at all times. On the basis of these relationships—along with assumptions about adjustment in the goods, financial assets, and money markets—we can determine the short-run movements of the exchange rate in response to a monetary disturbance. The link between the long run and short run, for the purpose of analyzing exchange-rate movements, can be operationally defined by the bond-market yield curve, which describes the yield on bonds of different terms to maturity. The underlying economic forces are fundamentally determined by liquidity considerations and market expectations about future money growth and inflation. To understand why exchange rates adjust differently in the short run than in the long run, we must understand why the yield curve varies in response to the forces noted here.

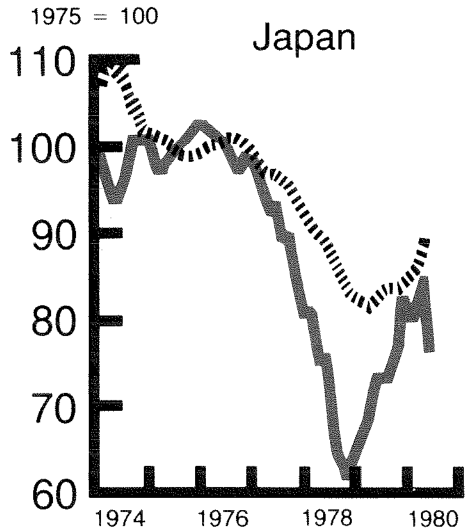
If the yield curve remains unchanged in response to a monetary change, then short-run and long-run exchange-rate adjustments would be indistinguishable. A change in excess money would lead to an immediate exchange-rate response, bringing the exchange rate immediately to its long-run equilibrium value—that value consistent with long-run purchasing-power parity. This response occurs even though adjustment in the goods market is not instantaneous, i.e., is lagged over a few years. If the yield curve changes, however, then

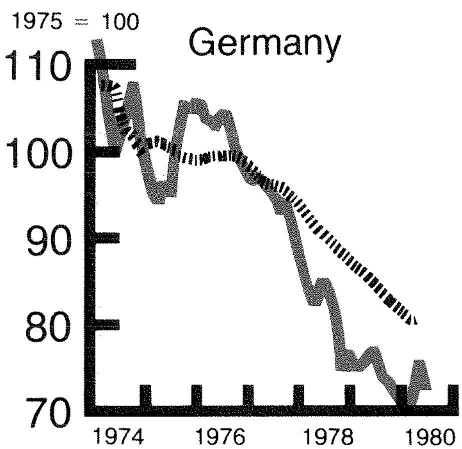
Chart 1

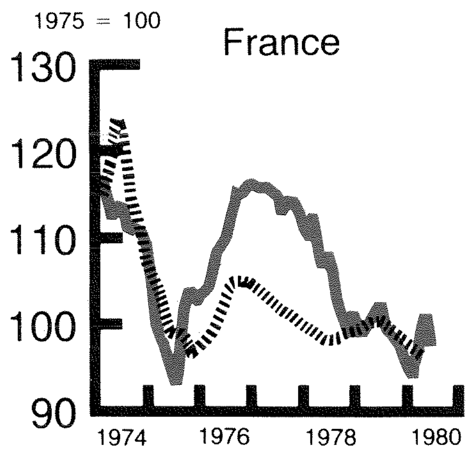
A Comparison of Exchange Rates and Prices











short-run and long-run exchange-rate adjustments would be different, as is explained in detail below.

To analyze the short-run movements of the system in response to a change in money supply, we must 1) distinguish between different types of changes in the money supply, and 2) make assumptions (based on observations) about the nature of the adjustment process in certain markets.

Money-supply Changes

There are two types of distinctions which should be made regarding money supply changes: a) permanent/transitory, and b) expected/ unexpected (Figure 1). The permanent (as opposed to transitory) change in the level of the money stock is that part which it is believed will not be reversed in the short run, i.e., the part that will result in a permanent change in the level of the money supply. Only the permanent part of the money-supply change is generally believed to affect economic behavior. This occurs because transactions are not costless, and if the public believes that money supply changes will shortly be reversed, they will avoid taking action and will temporarily absorb these balances in their holdings of money.[8] The expected money-supply change is the part which market participants anticipated in advance (by the length of the planning horizon), while the unexpected money-supply change is the difference between the actual and expected money-supply change. Thus, if individuals two years ago expected the money stock to rise by 5 percent this year, when in fact it rose by 15 percent, then 5 percent would represent the expected part, and 10 percent the unexpected part, of the change.

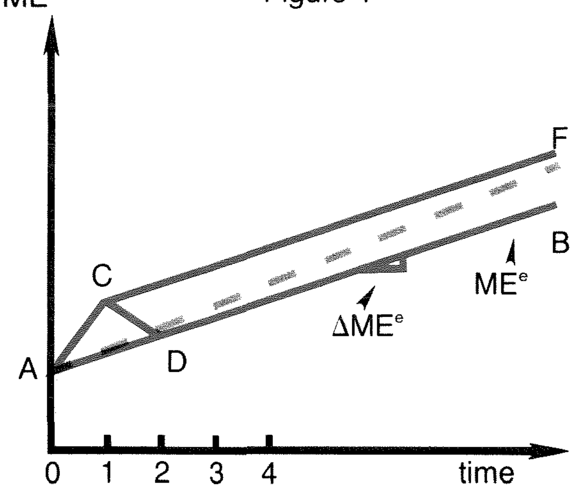
The line AB in Figure 1 is the expected path of excess money over some relevant planning horizon. ME^e is the level of excess money which is currently expected to exist at various points in the future. $\Delta(ME)^e$ is the expected growth in excess money. A movement from A to C represents a deviation of excess money from its expected growth path. Following such a move, excess money could proceed along either of two possible paths. 1) Actual excess money could move to D in the next time period, at which point it would be back on the previous expected path (AB). In this case, the deviation is only transitory, and the monetary disturbance would have no economic consequences for prices, interest rates or exchange rates. 2) Alternatively, actual excess money could proceed towards point F in succeeding time periods. This *permanent* change in the level of excess money, which was unexpected at the beginning of the planning period, could have definite effects on the economy. The price level would eventually be higher because point F is higher than point B. Also, short-run inflation expectations would be higher because the slope AF is greater than slope AB. However, long-run inflation expectations would remain unchanged. Such expectations are based on long-run excess money-growth expectations. With line CF extended into the "long run" (e.g., to point H), the slope of AH (long-run excess money growth) approaches the slope of AB (the previously expected long-run money growth). There would therefore be no change in expected long-run excess money growth or in long-run inflation expectations.

We assume that if actual money changes are expected and seen to be permanent (along line AB), there will be no lag between excess money and prices. In this specific case, contracts and other impediments to adjustment would be arranged to ensure that price changes occur when the money supply is expected to support the price change. Fully anticipated, permanent changes in the money supply thus lead to contemporaneous price increases, and the system therefore moves immediately to its new long-run equilibrium. In this case there are no short-run adjustments. In sum, because transitory money-supply changes have no effect on the economy, and because fully anticipated permanent changes result in an immediate move to the long-run equilibrium, we should concentrate on the results of a *permanent, unanticipated* change in the money stock (A-C-F). (To avoid awkward phrasing, the rest of the text will assume that all money changes are permanent, unless otherwise indicated.)

In this situation, the difference between the long run and the short run becomes important. In the goods market, prices will adjust only with a lag, and in the bond market there may be a shift in the term structure of interest rates (yield curve). These adjustment lags from an unanticipated money change could lead to short-run exchange-rate changes which are different from those resulting from an anticipated change in excess money—and which can cause purchasing-power parity not to hold in the short run. In the following discussion we will consider the different adjustment lags in the goods, money and bond markets, and further, consider their implications for exchange-rate adjustments.

Goods Market. The lags in the adjustment of goods prices in response to unanticipated money-supply changes have been well documented.[9] Two different types of lags can be differentiated. First, there is *recognition lag:* the time the market takes to recognize a change in the level of excess money and to differentiate between the permanent and the purely transitory part of that change. Given transaction and decision costs, individuals will delay changing their behavior until they are reasonably sure that a money change is permanent—that is, a move to F instead of to D in Figure 1. Secondly, there is *market-adjustment lag:* the time that goods-market prices take to adjust to recognized changes in excess money. Because of imperfect markets and information flows, there are lags between demand-and-supply shifts and changes in product prices.[10]

Figure 1



The existence of an organized secondary market in a product serves to eliminate the market-adjustment lag from the adjustment process.[11] These markets are organized so that changes in demand immediately become reflected in the price, i.e., the dealer or "auctioneer" moves the price immediately to equilibrate supply and demand, effectively eliminating any information problems. In addition, the factors which encourage the formation of organized markets also make these markets well suited for the activities of speculators and arbitrageurs. Once the recognition lag has passed, individuals realize that a price change is going to occur. Knowing this, market participants will buy or sell as soon as possible in anticipation of the price change, and this speculation causes the price change to occur right away. Because of these two factors, organized secondary markets do not exhibit a market-adjustment lag, but only a recognition lag, between the occurrence of a monetary disturbance and a resultant price change.[12] In contrast, products which are non-homogenous and/or expensive to store and transport, generally are not traded in organized secondary markets. As a consequence, we experience imperfect information flows, a lack of speculation and arbitrage, and therefore delays in price changes. Prices in most goods markets thus exhibit both recognition lags and market-adjustment lags in response to unanticipated money growth.

Money Market. To understand money-market adjustments, it is useful to review the money-price relationships of equations 1 and 2. These equations are based on an equality between the real supply and the real demand for money. In the present context, the relationship may be stated as follows:

$$m^s = m^d(y,R)$$

where m^s and m^d are the real supply and real demand for money respectively, and the real demand for money is a function of permanent real income (y) and the market interest rate (R). As seen above, an anticipated and permanent rise in the nominal supply of money will bring about a rise in goods prices contemporaneous with the rise in money supply, so that there will be no change in the real supply of money. In this case, there is no disturbance to the real demand for money—the only effect is a rise in prices. In contrast, an unanticipated but permanent rise in nominal money supply will lead to a lag in the adjustment of prices. In this case, the real supply of money will rise temporarily and require an adjustment in the real demand for money, thus affecting developments in the real economy, at least temporarily. Dornbusch (1976) in his article on exchange-rate overshooting, makes the standard assumption that the money market is always in equilibrium, i.e., that real money supply and real money demand are equal at all moments in time. If this is the case, then an increase in nominal money supply must be accompanied by an increase in the price level, an increase in real output, and/or a decrease in the nominal interest rate.[13] An increase in the price level would reduce real money supply, while an increase in real output or a fall in nominal interest rates would increase real money demand.

Given the slow adjustments of prices and output, continuous money-market equilibrium implies that the nominal interest rate must move immediately in order to equilibrate the real supply and real demand for money. Thus, a rise in the real money supply would lead to a fall in the market interest rate (liquidity effect). Once the goods-market adjustment is complete—initially through higher real income and eventually through higher prices—the interest rate in the bond market will return to its previous equilibrium value.

Our model does not differ in any fundamental way from this analysis, except that we allow for circumstances where the money market is in disequilibrium. Given goods-market disequilibrium, Walras' Law tells us that either the money market or the bond market, or both, must be out of equilibrium. It is reasonable to assume that the market interest rate moves to maintain equilibrium in the bond market, for which (unlike the money market) there are real-world primary and secondary markets. In that case, the goods market and the money market would be left out of equilibrium.[14] Such a result would occur if money were considered a "buffer stock", in much the same way that inventories may be out of equilibrium because of sudden shocks in either the supply or the demand side of the goods market.

Bond Market. As we have seen, the long-run effects of excess money on the bond market are purely expectational. Expected excess-money growth determines inflation expectations, and with the real interest rate given, determines the market interest rate. In the short run, an unanticipated increase in excess money can depress real market interest rates through a liquidity effect. But furthermore, it can tend to raise short-term interest rates through a rise in short-run inflation expectations. How is it possible to raise inflation expectations without a rise in long-run expected excess-money growth? Because a rise in excess money implies higher price levels once the goods-market adjustment is complete. This can raise short-run inflation expectations—the slope of AF is greater than the slope of AB—while leaving long-run inflation expectations unchanged.

A monetary disturbance can have offsetting liquidity and inflation-expectation effects on short-term interest rates. A rise in inflation expectations will shift the demand and supply of bonds so as to create upward pressure on the nominal interest rate. Thus, with interest rates determined by short-run equilibrium in the bond market, an unanticipated increase in excess money need not lead to a decline in market interest rates. Three conditions are possible, depending on the relative strengths of the two effects. 1) The liquidity effect is less than the short-run inflation expectation effect, pushing up short rates, leaving long rates unchanged, and thus causing a shift toward a more negative sloping yield curve. 2) The liquidity effect is greater than the expectation effect, causing a decline in short-run market rates and a shift toward a more positively sloping yield curve. 3) The liquidity effect is equal to the inflation-expectation effect, leaving market interest rates and thus the yield curve unchanged. Thus, short-run equilibrium in the bond market is consistent with different shifts in the slope of the yield curve, which means consistent with different exchange-rate adjustments.

Exchange Adjustments

Now that we have considered the short-run equilibrium conditions in domestic markets for money, goods and bonds, we can proceed to analyze the developments between countries which operate through foreign-exchange rates. The key assumption linking goods markets between countries is purchasing-power parity (equation 6), and the key assumption linking bond markets between countries is nominal interest-rate parity (equation 9). Because of the relatively long adjustment lags in the goods market, movements in the bond market will determine short-run movements in the exchange rate.

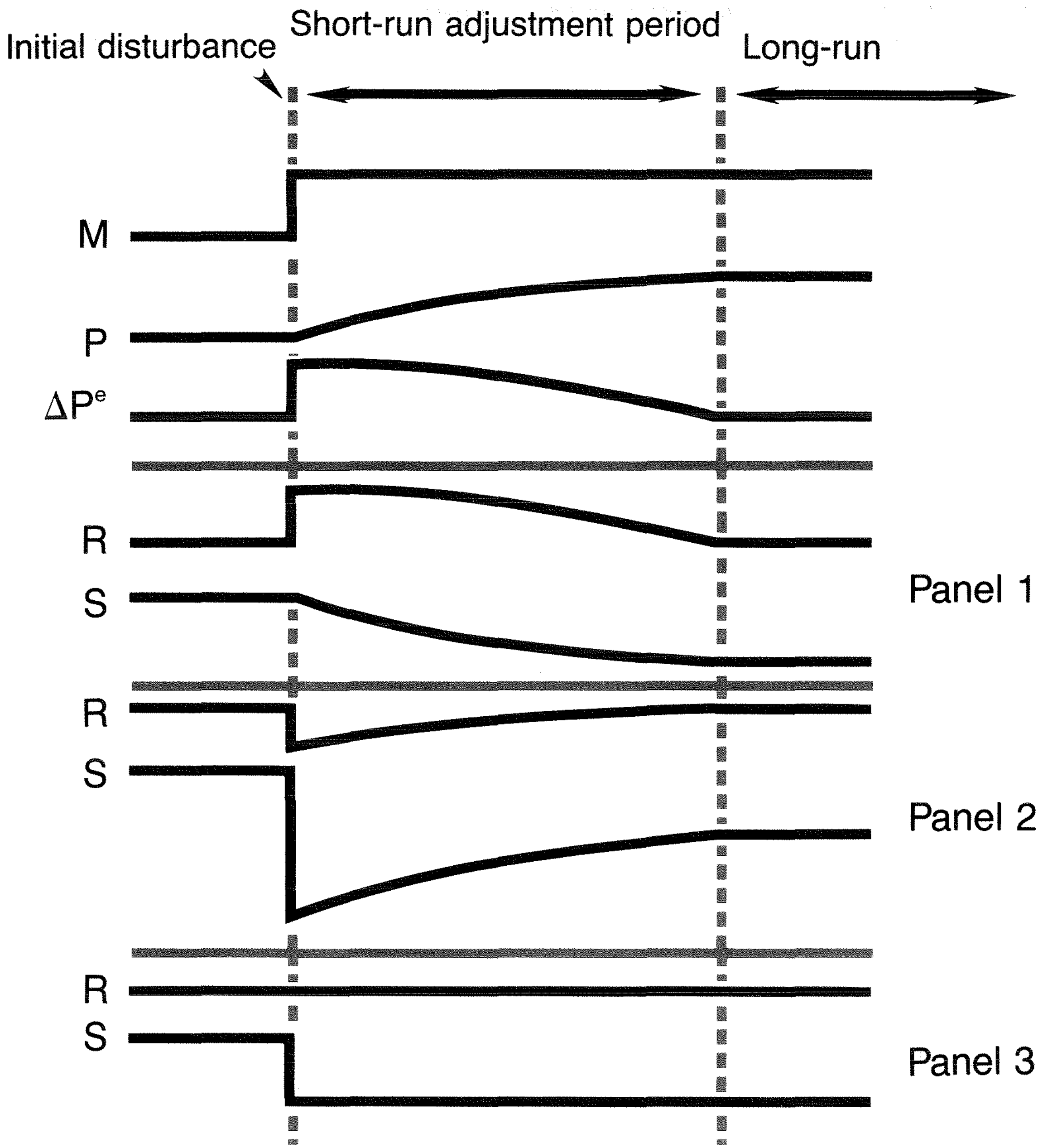
Under the assumption of perfect capital mobility, equation 9 represents a short-run condition which holds at all times.[15] The condition states that asset holders will be fully compensated for the expected depreciation of the currency in which their assets are denominated, i.e., that the nominal interest rate in one country will exceed the nominal interest rate of the foreign country by the amount of the expected depreciation of the domestic currency. If this condition did not hold, asset holders would be induced to shift out of the assets of one country into foreign assets in order to preserve the real purchasing power of their bonds. This would put immediate pressure on the exchange rate and/or the nominal interest rate, and drive the system back to the condition of nominal interest-rate parity. Thus, short-run profit possibilities create incipient capital flows which serve to maintain this condition. Short-run exchange-rate movements are therefore integrally related to movements in short-run interest rates.

Short-run movements of the exchange rate can be better understood by examining the effects of three different types of monetary changes.

The first situation involves a one-time *unanticipated but permanent* increase in the level of excess money (Figure 2). Assume that there is a 5-percent increase in domestic excess money (top line in Figure 2), that prices take one year to fully adjust to this disturbance, and that both the interest rate and expected inflation rate are one-year rates. In the long run, the effects of this disturbance will be a 5-percent rise in the domestic price level and a 5-percent fall in the exchange rate, with no change in the level of interest rates. In the short run, prices (P) would be expected to rise gradually over the course of a year and remain stable thereafter, at a level 5 percent higher than before the disturbance. Therefore, one-year inflation expectations (ΔP^e) will initially rise by 5 percent and then gradually return to their initial level. Long-run inflation expectations will be unchanged. The possible short-run adjustment paths are outlined in panels 1-3, corresponding to the three bond-market conditions cited above.

Panel 1). An extreme case where short-term interest rates increase to fully incorporate the expected price inflation, i.e. an initial 5-percentage-point rise in the short-term interest rate. This implies no liquidity-induced decline in the real rate of interest. (Recall that given slow adjustment of output, this rise in nominal rates also implies money-market disequilibrium). Under these circumstances the exchange rate should move toward its long-run value only gradually, at the same speed as the price level, i.e., the spot exchange rate moves so that purchasing-power parity is maintained at all times. The expected short-run depreciation of the exchange rate equals the expected short-run price increase (both 5 percent over one year). The compensating rise in short-term interest rates relative to long-term rates leads to a gradual depreciation of the currency.

Figure 2
Alternative Adjustments to a Monetary Disturbance



Note: For expositional purposes, we assume a one-year adjustment period between money and prices, and interpret the interest rate and expected inflation rate as one-year rates.

Panel 2). An opposite extreme where short-run market interest rates decline by the full amount necessary to maintain continuous money-market equilibrium. In this case, the short-run inflation-expectations effect is completely dominated by the liquidity effect. Not only are asset holders uncompensated for a decline in the real purchasing power of their security, they are also forced to accept a lower market-interest rate than they did before the unanticipated rise in excess money. This combination of circumstances will induce market participants to attempt to switch out of domestic assets into foreign assets, which will cause an immediate depreciation of currency by more than the 5-percent increase in excess money. Thus, given a decline in both real *and nominal* short-term interest rates, the exchange rate must depreciate to a level below its expected long-run value. This overshooting of the exchange rate (as described by Dornbusch), leads to an expected appreciation of the exchange rate over time. The expected appreciation of the domestic currency compensates for the lower domestic interest rate, and the interest-rate parity condition (equation 9) is maintained. In general, as long as the liquidity effect is greater than the inflation-expectation effect, there will be a shift toward a more positive-sloping yield curve as well as a temporary overshooting of the exchange rate.

Panel 3). An intermediate case, where the inflation-expectation effect exactly offsets the liquidity effect. In this panel, as in panel 2, asset holders are not compensated for the expected depreciation (a decline in the real purchasing power of their bonds), so that they attempt to shift out of domestic assets into foreign assets. This immediately depreciates the exchange rate. With no change occurring in the nominal interest-rate differential, the exchange rate must depreciate immediately by 5 percent to its long-run equilibrium value.

The long-run effects under each of the above assumptions are equivalent. However, the choice of assumption about the adjustment in the money and bond markets is critical in explaining short-run exchange-rate movements. Given our assumptions about goods prices and capital mobility, the existence of a liquidity effect ensures that the exchange rate will adjust more rapidly than prices in response to a monetary disturbance.

We can deal with the other types of monetary changes rather quickly. The second example of a monetary change involves a *fully anticipated and permanent* increase in the level of excess money movement along AB (in Figure 1). Because of the expected nature of this increase, inflation expectations and therefore nominal interest rates of all maturities have already adjusted—that is, domestic bond holders are being compensated for the higher (short-run) inflation. Both prices and the exchange rate should rise contemporaneously with the money increase, with no effect therefore on real money balances, the real interest rate, inflation expectations, or the market interest rate.

A final example involves an increase in the permanent growth rate of excess-money—that is, a change in the slope of the expected excess-money path. This represents a combination of two previous disturbances—an unanticipated increase in the level of money, followed by further anticipated increases, which are larger than previously anticipated. The short-term effects will therefore be similar to those in the first situation described above. The long-run effects will be similar to those in the second situation, although with increased long-run inflation expectations as well as short, reflecting the permanent alteration in the money-growth rate.[16] The higher level of inflation expectations will therefore lead to higher market-interest rates (long and short). The currency will depreciate gradually over time, coincident with and equal in size to the increase in the price level. But no profit opportunities will emerge in the bond market, because interest differentials will adjust to compensate fully for the expected inflation and for the exchange-rate depreciation.

The key, therefore, to understanding short-run movements in the exchange rate is to understand the effects of unanticipated excess money on the bond market. Theoretically, the effects are ambiguous in the short run, so that an appeal to the evidence is needed to resolve the question.

III. Testing the Hypothesis

We are now in a position to write the equations which will be estimated. These estimates will be used to test our theoretical conjectures and make inferences about both the long- and short-run adjustments of prices and exchange rates.

$$\Delta(P^* - P)_t = a_o' + \sum_{j=o}^{m} a_j \Delta (ME^* - ME)_{t-j} \quad (10)$$

$$\Delta S_t = b_o' + \sum_{j=0}^{n} b_j \Delta (ME^* - ME)_{t-j} \quad (11)$$

where m represents the length of the adjustment period between excess money and prices, and n represents the length of the adjustment period between excess money and exchange rates.

First we ask whether we can confirm the long-run relationship between excess money and prices, and between excess money and exchange rates. Further, we ask whether we can confirm that the long-run coefficients in the excess money/price relationships are equal to those in the excess money/exchange-rate relationships (i.e. $\Sigma b_j = \Sigma a_j$ for each country). For these tests, the distinction between expected and unexpected is not relevant, because the long-run effects of a money change on prices and exchange rates are the same in either case.

This is not so in the short run, however, because as we have seen, short-run adjustments of the system depend on whether the monetary change is expected or unexpected. In particular, if all money changes were expected, both prices and exchange rates should adjust contemporaneously with money, (i.e., m and n would equal zero). In contrast, if all money changes were unexpected, the money/price lag (m) should be long, while the money/exchange-rate lag (n) should depend on the short-term interest rate. In this connection, the existence of the liquidity effect on short-term interest rates ensures that adjustment will occur more quickly in exchange rates than in prices. This then raises the question whether or not excess money changes affect exchange rates more rapidly than they affect price-level ratios.

The unexpected/ expected distinction is easy to make conceptually, but difficult to make empirically.[17] Thus, we do not attempt to break down actual changes in excess money supply into expected and unexpected components. Money-supply changes over time undoubtedly have contained both of these components, so that we should see some combination of instantaneous and lagged adjustments in goods prices and foreign-exchange rates. All else equal, the greater the unexpected component relative to the expected component, the longer should be the lags between money and prices.[18]

Next, we estimate the long-run interest-differential equation. Differentials across countries (R_L^*-R_L) are a function of differences in long-run inflation expectations, and thus are due to differences in expected excess-money growth. The latter is determined not only by past excess-money growth, but also by other factors which market participants have found to be good indicators of future money growth, such as government budget deficits. Non-monetary factors are not directly included in our estimating equation, but any systematic movement in these variables could be captured through a Cochrane-Orcutt correction. Thus we obtain the following:

$$(R_L^* - R_L)_t = c_o' + \sum_{j=o}^{p} c_j \Delta (ME^* - ME)_{t-j} \quad (12)$$

The role of relative excess money growth in equation 12 is fundamentally different from that in equations 10 and 11. Equation 12, unlike equations 10 and 11, is designed to capture the effect of past actual money growth on expectations of money, providing evidence whether government authorities have changed the long-run target of future money growth. This is therefore a form of a central-bank reaction function. Past money growth's only role in this equation is as a generator of changes in inflation expectations. It has no role in either the state of the business cycle or the state of liquidity in the economy.

Next, we estimate short-run interest-rate differences across countries (R_s^*-R_s), which have a more complex relationship than long-run differences to current and past excess-money growth. This is because short rates are influenced by both liquidity and inflation expectations.

$$(R_s^* - R_s)_t = d_o' + \sum_{j=o}^{q} d_j \Delta(ME^* - ME)_{t-j} \quad (13)$$

The relationship between excess money and short-term interest-rate differentials may be positive if short-run inflation expectations dominate the relationship ($\Sigma d_j > 0$); it may be negative if liquidity effects dominate ($\Sigma d_j < 0$); and it may be approximately zero if the two effects offset one another. In addition, the sign of the d_js may vary between negative and positive if the liquidity effect dominates in the early months, and if the inflation-expectations effect dominates thereafter.

Although we cannot make any *a priori* statements about the relationship between short-term interest rate differentials and excess money growth differentials, we can say the following: a) If liquidity effects have any influence on short-term interest rates, then the exchange rate will adjust more rapidly than prices i.e., the difference between the money/price mean lags and the money/exchange rate mean lags should be relatively large. b) If liquidity effects initially dominate short-term interest-rate movements, then the exchange rate should overshoot the long-run equilibrium value, i.e., the short-run effects of excess money on the exchange rate should be greater than the long-run effects. c) If the liquidity effect has no influence on short-term interest rates and inflation expectations effects dominate initially, then the exchange rate should move more in line with prices—i.e., the difference between the money/price lags and the money/exchange rate lags should be relatively small.

IV. Empirical Estimation

To test the theory, we chose empirical measures which were as simple as possible, consistent with the variables in the theory. We measured the exchange rate in all cases as the monthly average of the bilateral rate between the U.S. dollar and the foreign currency (measured as foreign currency per dollar). For a money-supply measure, we chose the broad measure of money plus quasi-money from the IMF's **International Financial Statistics,** seasonally adjusted using an X-11 routine. The broad measure was used here because it was found to be generally superior to the narrow money-supply measure in earlier work of one of the authors (Keran, 1979), although both measures provided significant results with respect to exchange rates. For prices, we chose the wholesale-price indexes from **International Financial Statistics,** and again used an X-11 routine for seasonal adjustment. For interest rates, we chose 3-4 month representative money-market rates and long-term domestic government bond yields from Morgan Guaranty's **World Financial Markets.**

As a proxy for real money demand, we constructed a 36-month moving average of actual real money balances. This procedure is consistent with the assumption of noncontinuous equilibrium in the money market, and it reduces the complexity of both the model specifications and the statistical estimates. In using this proxy, we assume that purely transitory changes in real money demand have no effect on prices or exchange rates because they are expected to be reversed. We also assume that real money demand and real money supply are equal over the long run, which is defined as that time period in which prices adjust to a monetary disturbance. This period of adjustment may vary between countries, but presumably in each case is completed within three years—hence our choice of a 36-month moving average.[19]

All of the equations were estimated using the Almon polynominal distributed-lag (PDL) technique, which helps us distinguish between the permanent and transitory changes in excess money. Each equation was run a number of times, with different lag lengths ranging from 0 to 36 months and up to 4th degree polynomials. In all cases the far ends were constrained equal to zero. The "best" total number of lags and degree were chosen based on the criterion of lowest standard error of the regression. All of the equations were estimated with monthly data for the period January 1975-December 1978.[20]

We present the results from the "best" money/price equations for each country in Table 1, and the results from the "best" money/exchange-rate equations in Table 2. Tables 5 and 6 show the long- and short-term interest-rate results. In presenting the statistical results, we analyze a number of statistical measures which are briefly discussed in Appendix 1.

Money and Prices

Our results (Table 1) clearly support the theoretical belief in a significant relation between an increase in excess money and a rise in the price of goods, with the price lags reflecting a host of contractual, informational, and inventory adjustments. The t-statistics on the sum of lag coefficients are all a good deal greater than 2 (averaging 5.0), which confirms that the monetary variable is significant in explaining the inflation differential between countries.

The values of the Durbin-Watson statistics allow us to reject the possibility of autocorrelation in the errors. The lack of systematic errors in these equations is consistent with the notion that we have not left out any significant systematic explanatory variables. The total lag lengths ranged from 12 months for Italy to 36 months for France and Switzerland, with an average across countries of about 24 months. Lags longer than these only decreased the explanatory power of the equation. The time required for 75 percent of the total effect to occur ranged from 10 months for Italy to 30 1/2 months for France.

Money and Exchange Rates

As with money and prices, the evidence clearly supports a significant link between money and exchange rates (Table 2). The sum of the coefficients on the monetary variable are significant for all five bilateral exchange rates. While the $\bar{R}^2$s may seem low, all of the variables in the exchange-rate and price equations are measured in monthly percentage-change form, so that there is a great deal of unsystematic and random "noise" in the series

Table 1
Relationship of Changes in Wholesale Price Ratios and Excess Money, 1975–78

$$\Delta(P^* - P)_t = a_o' + \sum_{j=o}^{m} a_j \Delta (ME^* - ME)_{t-j}$$

Country	Total No. Lags	75% Effect Lag	Constant	Σ Lagged Coefficients	$\bar{R}^2$	S.E.R.	Rho	D.W.
France	36	30.5	−.0021 (−1.81)	3.74 (4.94)	.338	.0066	—	1.66
Germany	18	14.5	.0012 (1.10)	1.33 (4.12)	.263	.0037	—	1.67
Italy	12	10.0	−.0196 (−5.26)	3.07 (6.58)	.760	.0052	—	1.63
Japan	18	15.0	−.0031 (−5.26)	1.36 (6.64)	.511	.0039	—	1.71
Switzerland	36	30.0	.0005 (.22)	2.30 (3.30)	.183	.0048	—	1.82

t-statistics in parenthesis

which is not explained by the independent variable.[21]

Table 3 presents the sum of the lag coefficients for the price and exchange rate equations, the difference between the coefficients, and the t-statistics on each.[22] The exchange-rate coefficients are larger than the price coefficients for all countries except France, but in no case is there a statistically significant difference between the long-run price and exchange-rate coefficients. This is consistent with our theoretical argument that the long-run coefficients in the two sets of equations would be equal.

Next, consider the cumulative effects of excess-money changes on price ratios and exchange rates (Chart 2). This chart shows the total effect of an initial one percent change in excess money for any month in the adjustment period. Because the adjustment period is never longer than 36 months, the value plotted at lag 36 will be equal to the sum of the lag coefficients estimated in equations 10 and 11.

Exchange-rate overshooting, which occurs when excess money depresses short-term interest rates via the liquidity effect, should be indicated by a distributed lag in the exchange-rate equation consisting of positive coefficients followed by negative coefficients, with the sum equal to that in the price equation. Such overshooting was evident only in the case of Switzerland, for it was the only country showing significant negative coefficients in the lag patterns of the exchange-rate equations. This can be clearly seen in the pattern of exchange-rate lagged coefficients, where the cumulative effect first rises above the long-run value. The evidence in the short-term interest-rate equations is also consistent with this liquidity/overshooting explanation.

Table 3
Long-run Coefficients of Exchange Rate and Price Equations

Country	(1) Exchange Rate Equation	(2) Price Equation	(1)-(2) Difference
France	3.44 (2.94)	3.74 (4.94)	−.29 (−.27)
Germany	3.09 (2.37)	1.33 (4.12)	1.76 (1.33)
Italy	3.31 (3.15)	3.07 (6.58)	.24 (.22)
Japan	1.89 (2.79)	1.36 (6.64)	.53 (.82)
Switzerland	3.17 (2.97)	2.30 (3.30)	.87 (.76)

(t-statistics in parenthesis).

Table 2
Relationship of Changes in Exchange Rates and Excess Money, 1975–78

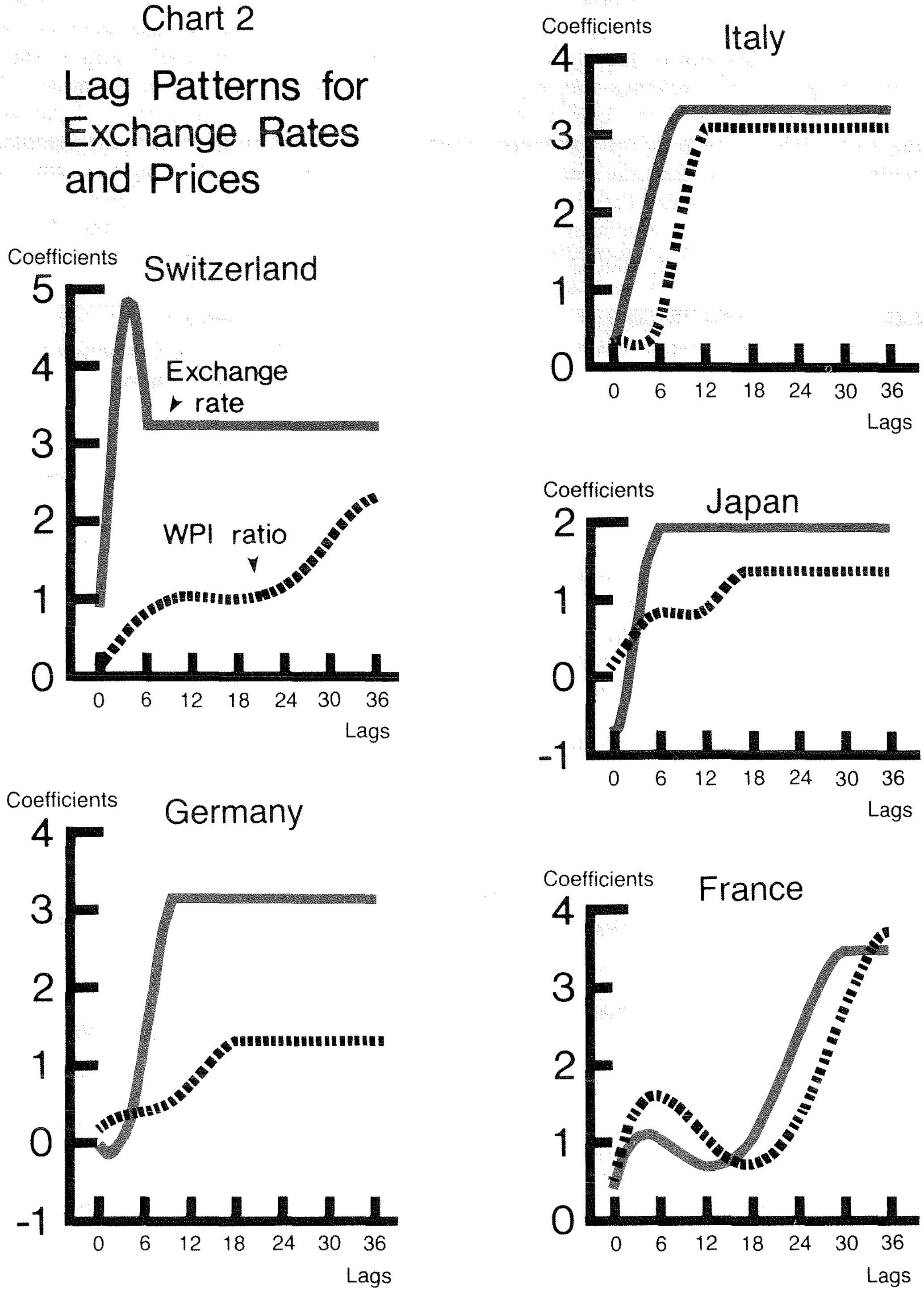
$$\Delta S_t = b_o' + \sum_{j=0}^{n} b_j \Delta (ME^* - ME)_{t-j}$$

Country	Total No. Lags	75% Effect Lag	Constant	Σ Lagged Coefficients	$\bar{R}^2$	S.E.R.	Rho	D.W.
France	30	25.0	−.0008 (−.25)	3.44 (2.94)	.124	.0184	—	2.00
Germany	9	7.5	.0044 (.91)	3.09 (2.37)	.118	.0196	—	1.88
Italy	9	5.75	−.0252 (−3.02)	3.31 (3.15)	.675	.0131	—	1.58
Japan	6	4.5	−.0037 (−2.37)	1.89 (2.79)	.168	.0204	—	1.67
Switzerland	6	1.0	.0057 (.98)	3.17 (2.97)	.335	.0229	—	1.50

t-statistics in parenthesis

Chart 2

Lag Patterns for Exchange Rates and Prices



*The coefficients charted above show the *cumulative* effects of a monetary disturbance on the exchange rate and the WPI ratio, and are derived by cumulatively adding the lag coefficients estimated in equations 10 and 11.

The exchange-rate equations are notable for the shortness of the lags between money and exchange rates (Table 4). For all countries except France, the total lag ranged between 3 and 9 months, and averaged about 7 months; for France, the lag was 30 months. Similarly, the 75-percent effect—the time required for 75 percent of the exchange-rate impact to occur—ranged below 8 months for all countries except France (25 months). We may conclude that money affects exchange rates more rapidly than it does prices, judging from the evidence that both the total and 75 percent-effect lags were substantially less in the exchange-rate equations than in the price equations. According to our theoretical model, these shorter lags are consistent with monetary disturbances resulting in changes in real interest rates (liquidity effects). We will see that the evidence from the short-term interest-rate equations is consistent with this theory.

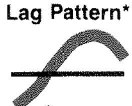
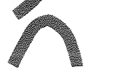
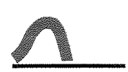
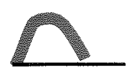
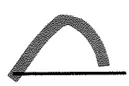
Our model is incomplete because it captures the real terms-of-trade effect on the exchange rate only in the constant term. Admittedly, this is unrealistic. For example, one of the authors (Keran, 1980) has shown that the yen/dollar

Table 4
Money-Exchange Rate and Money-Price Lags
(in months)

	Exchange Rate Equation		Price Equation		
Country	**(1) Total Lag**	**(2) 75% Effect Lag**	**(3) Total Lag**	**(4) 75% Effect Lag**	**(4)-(2) Difference**
France	30	25	36	30.5	5.5
Germany	9	7.5	18	14.5	7.0
Italy	9	5.75	12	10.0	4.25
Japan	6	4.5	18	15.0	10.5
Switzerland	6	1.0	36	30.0	29.0

Table 5
Relationship of Long-term Interest Differential and Changes in Excess Money, 1975–78**

$$(R_L^* - R_L)_t = c_o' + \sum_{j=o}^{p} c_j \, \Delta \, (ME^* - ME)_{t-j}$$

Country	**Total No. Lags**	**Constant**	**Σ Lagged Coefficients**	**$\bar{R}^2$**	**S.E.R.**	**Rho**	**D.W.**	**Lag Pattern***
France	36	1.88 (14.88)	.07 (1.84)	.909	.2127	.71 (6.93)	2.05	
Germany	21	.06 (.15)	.45 (4.63)	.968	.2425	.88 (12.65)	2.26	
Italy	18	−1.83 (−2.04)	.52 (6.11)	.843	.5074	.59 (5.05)	1.89	
Japan	24	−0.50 (−3.07)	.29 (8.03)	.972	.2044	.82 (7.68)	2.48	
Switzerland	30	−2.88 (−5.93)	.38 (4.47)	.973	.2153	.89 (13.26)	2.61	

*Shaded areas indicate not significantly different from zero.
t-statistics in parenthesis
**In order to better interpret the coefficients of these equations, annualized percentage changes in excess money are used instead of the difference of logs.

exchange rate is significantly affected by the real price of oil. Real terms-of-trade factors are beyond the scope of this paper, but they still remain important.

Money and Long-Term Interest Rates

We obtain quite strong results from the equations estimating the relationship between long-term interest rates and the growth in excess money (Table 5). Relative to the U.S., all countries show a significant positive relationship between the level of the interest-rate differential and the growth rate in excess money.[23]

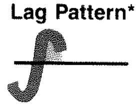
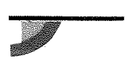
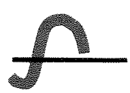
The link reflects the fact that changes in long-term interest rates are due primarily to changes in long-run inflation expectations, which in turn are based on expected future excess-money growth. Forecasts of future money growth often depend on the pattern and size of current and past money-growth rates. Therefore we obtain a significant statistical correlation between the level of the long-term interest differential and current and past growth rates of excess money. The t-statistics on the sum of lag coefficients ranged from just under 2 for France to more than 8 for Japan. Before adjustment for autocorrelation, the DW statistics were extremely low, suggesting that important variables were omitted from the equation—and indeed, we excluded from our equation other data which individuals might use to forecast future money growth and future inflation. Nonetheless, these results and the money-price results confirm the relationship between excess money-growth differentials on the one hand, and current and expected future inflation differentials on the other.

Money and Short-Term Interest Rates

Our empirical results reflect the ambiguity of our theoretical argument, that an increase in excess money can simultaneously have a liquidity effect which reduces short-term rates and an inflation expectations effect which increases short-term rates (Table 6). In the cases of France and Switzerland, the liquidity effects dominate initially; in the cases of Germany and Japan, the results are not significant, reflecting offsetting effects; and in the case of Italy, the inflation-expectation effect dominates initially. The evidence (except for France) also supports our theory that countries with the greatest liquidity effects would show the larg-

Table 6
Relationship of Short-term Interest Differential and Changes in Excess Money, 1975–78**

$$(R_s^* - R_s)_t = d_o' + \sum_{j=o}^{q} d_j \Delta(ME^* - ME)_{t-j}$$

Country	Total No. Lags	Constant	Σ Lagged Coefficients	R^2	S.E.R.	Rho	D.W.	Lag Pattern*
France	15	−.35 (−.16)	−0.13 (−.61)	.881	.7847	.95 (20.18)	1.98	
Germany	15	−692.82 (−1.43)	−.30 (−1.53)	.903	.5464	1.00 (381.63)	1.82	
Italy	21	−12.61 (−3.54)	1.87 (5.49)	.913	1.2385	.74 (7.73)	1.72	
Japan	24	−5.08 (−1.72)	.25 (1.22)	.958	.6729	.97 (28.35)	1.24	
Switzerland	24	−2.74 (−6.32)	.64 (7.32)	.894	.7270	.58 (4.90)	2.17	

*Shaded areas indicate not significantly different from zero.
t-statistics in parenthesis
**In order to better interpret the coefficients of these equations, annualized percentage changes in excess money are used instead of the difference of logs.

est differences between the lags in the price and exchange-rate equations, and that countries with large inflation-expectation effects would show the lags in the exchange rate closely corresponding with the lags in goods prices. With the exception of France, the evidence is consistent with this theory. Switzerland has a significant initial liquidity effect, overshooting in the exchange rate, and the largest difference between the price and exchange rate 75-percent-effect lags; Italy has a significant initial inflation-expectation effect and the smallest difference in these lags; and Germany and Japan have insignificant inflation-expectation and liquidity effects, with differences in these lags falling between those of Switzerland and Italy. Switzerland shows a significant initial liquidity effect which is accompanied by an overshooting of the exchange rate. France also shows a significant liquidity effect, but does not show a rapid adjustment of the exchange rate. This may perhaps be explained by France's pervasive system of capital controls.[24] Again, before adjustment for autocorrelation, the DW statistics were extremely low in these equations, indicating the probable omission of systematic explanatory variables.

V. Summary and Conclusions

It has long been believed and is now widely accepted that exchange rates in the long run will be determined by purchasing power parity. That is, the exchange rate will be largely determined by equilibrium conditions in the goods market. Because of the slow adjustment of this market to economic disturbances, it was generally assumed that the exchange rate would also adjust relatively slowly. In fact, however, variations in the exchange rate have been considerably greater than variations in prices across countries.

These facts have not shaken most analysts' views about the long run validity of purchasing-power parity. As Figure 1 indicates, exchange rates do, in fact, move in line with the ratio of national price levels over the long run. However, the relatively large short-run deviations from purchasing-power parity require an explanation. In analyzing short-run movements in exchange rates, most analysts focus on the role of interest-rate parity. Interest-rate differentials across countries can influence capital flows and thus exchange rates.

Research in this area has focused on the use of money-market equilibrium models for interest-rate determination (see, for example, Dornbusch 1976). Given lags in the adjustment of the goods market, an increase in the supply of money, in these models, will necessarily lead to a decrease in interest rates (so-called liquidity effect) and thus to a temporary decline of the exchange rate below its long-run equilibrium value. Later, as the goods market responds to this monetary disturbance, interest rates will gradually rise and the exchange rate will appreciate back to its long-run value. This temporary overshooting leads to greater variation in exchange rates than in the ratio of national price levels.

In this article, we evaluate the short-run relationship between interest rates and exchange rates. In our short-run model, interest rates are determined in the bond market, rather than in the money market. This circumstance permits a wider range of interest-rate responses to a monetary disturbance.

An increase in the money supply can have both a short-run liquidity effect and a short-run inflation-expectation effect (Figure 2). These effects have opposite implications for interest rates. 1) If the liquidity effect is dominant, then short-run interest rates will decline and there will be exchange-rate over-shooting. 2) If the inflation-expectation effect is dominant, then interest rates will rise and the exchange rate will move slowly to its long-run equilibrium value. 3) If the liquidity and inflation-expectation effects are equal, there will be no change in short-term interest rates and the exchange rate will move immediately to its long-run value.

A comparison of the U.S. experience, vis-a-vis five major industrial countries, shows that: 1) For all countries, there is a statistically significant relationship between the monetary disturbance on the one hand, and exchange rates and the ratio of national price levels on the other.

2) There is no statistically significant difference between the long-term effects of a monetary disturbance on the ratio of national price levels and on exchange rates.

3) The exchange rate responds on the average much more quickly than the ratio of national prices to a monetary disturbance.

4) In only one country (Switzerland), is there evidence of exchange-rate overshooting in the short run. In three countries (Germany, Japan, Italy), the exchange rate moves quickly to its equilibrium value without overshooting, and in one country (France), exchange-rate movements were roughly in line with price movements.

The analysis and research in this paper show that interest rates do, in fact, play an important role in short-run exchange-rate movements. However, it is the equilibrium conditions in the bond market (not the money market) which determine short-term interest rates and thus exchange rates. These interest-rate movements are the source of greater short-run variations in exchange rates than in the ratio of national price levels.

APPENDIX
Description of Statistics

t-statistic on the coefficients: The t-statistic, which is equal to the ratio of the coefficient to its estimated standard error, is a key determinant of the statistical significance of the independent variable in explaining movement of the dependent variable. In our equations, a t-statistic greater than about 2 in absolute value indicates that the corresponding coefficient is significantly different from zero at the 95-percent coefficient level. t-statistics are calculated on each lagged coefficient and also on the sum of all lagged coefficients. The t-statistic on the sum, which is reported in the tables, tells us whether or not the long-run effect of the independent variable is significant in explaining movement in the dependent variable.

Adjusted $R^2(\bar{R}^2)$: The $\bar{R}^2$ tells us how much of the variance in the dependent variable can be explained by the variance in the independent variables, after adjusting for the number of observations and the number of independent variables. The $\bar{R}^2$ can be a misleading measure of goodness of fit if it is used to compare equations estimated in different dimensions, such as level and percent-change form. The $\bar{R}^2$ will usually be much lower in the change form than the level form, because of greater random variation relative to the systematic variation in the change form than in the level form. In this case, a better measure of goodness of fit is the standard error of the regression.

Standard error of the regression (SER): This is another measure of the explanatory power of the equation. It measures the degree to which the estimated values of the dependent variable differ from the actual values. Given a normal distribution of errors, we would expect that the fitted value of the dependent variable would be within one standard error (plus or minus) of the actual value 66 percent of the time.

Durbin-Watson statistic (DW): This statistic tests for first-order autocorrelation, i.e. systematic errors in the estimated equation. A common cause of systematic error is the omission from the equation of at least one significant explanatory variable. For our particular equations, DWs of greater than 1.6 indicate, with 95-percent confidence, a lack of positive autocorrelation. In testing for negative autocorrelation, DWs of less than 2.4 indicate, with 95-percent confidence, a lack of negative correlated errors. If the DWs fall between 1.2 and 1.6 or between 2.4 and 2.8, then the respective tests of autocorrelation are indeterminate—that is, we cannot conclude from the tests whether or not systematic errors are present. DWs of less than 1.2 indicate significant positive first-order autocorrelation, and DWs greater than 2.8 indicate significant negative first-order autocorrelation of the errors.

FOOTNOTES

1. These models usually have involved analyses of the effects of changes in inflation expectations. In the monetary approach, a rise in inflation expectations will reduce the real demand for money, putting additional upward pressure on prices which is initially observed in the foreign-exchange rate. In the portfolio approach, a change in inflation expectations, operating through the bond market, will reduce the desired holdings of assets in the inflating currency and thus affect the exchange rate. The monetary approach assumes prompt adjustment in the goods market to a monetary disturbance which is observed in the exchange rate but (because of measurement error) not observed in price indexes. In the portfolio approach, goods markets presumably adjust with a lag, but the bond market responds immediately and thus affects the exchange rate. Either of these approaches could explain a short-run exchange-rate change which is greater than observed changes in the ratio of national price levels. Both approaches accept implicitly or explicitly the assumption of long-run purchasing-power parity.

2. For an opposing viewpoint on currency substitution and a discussion of the effects on the exchange rate, see Wallace (1978, 1979).

3. The terms of trade measure the long run value of one country's goods in terms of the value of another country's goods, e.g., how many bushels of U.S. wheat it takes to "purchase" one Japanese TV set. A change in the terms of trade could be caused by a change in technology, the discovery of new sources of raw materials, or a substantial change in relative prices of important commodities, such as a rise in the price of oil. We assume here that terms of trade changes are independent of monetary factors.

4. Equation 8 assumes that risk premiums are equal across countries. This is done for simplicity and is not necessary for the model. All that we really need to assume for the model to hold is that these risk premiums are constant across time, i.e., $r = r^* + c$. We are not attempting in this paper to model the consequences of long run changes in the real interest rate.

5. Equation 9 can be derived as follows:

$$R = \Delta P^e + r \qquad \text{5a)}$$

$$R^* = \Delta P^{*e} + r^* \qquad \text{5b)}$$

$$\Delta S^e = \Delta P^{*e} - \Delta P^e \qquad \text{7)}$$

$$r = r^* \qquad \text{8)}$$

Substituting 5a) and 5b) into 8 we get:

or $R - \Delta P^e = R^* - \Delta P^e$
or $R = R^* - (\Delta P^e - \Delta P^e)$

Substituting equation 7 into this, we arrive at equation 9:

$$R = R^* - \Delta S^e \qquad \text{9)}$$

6. This topic is discussed in Bilson (1979).

7. Even in the long run, the relationship will not be exact, because price indexes in two different countries will not necessarily have the same weights. That is, even if individual goods are priced the same in two countries, the price indexes may not necessarily have the same value in the two currencies because of differences in the composition of the indexes. To minimize these cross-country measurement problems, wholesale rather than consumer prices are used here. Furthermore, the existence of long-run purchasing-power parity does not imply anything about the direction of causality, the theory only requires that prices and exchange rates move together. Not only will prices affect exchange rates, but exchange rates will also affect prices. The crucial factor determining both prices and exchange rates is the difference in excess money growth between countries.

8. See Carr and Darby (1977) and Tucker (1971).

9. Charles Pigott discusses these lags in his article in this issue, "Expectations, Money and the Forecasting of Inflation."

10. The market-adjustment lag also includes the time it takes for a monetary disturbance, once recognized, to alter individuals' behavior. This lag arises because each individual tends to economize on decisions and transactions, and thus changes his behavior only periodically, even after the monetary change is considered permanent. On the aggregate level, this implies a gradual change in demand and supply.

11. A large number of organized, auction-type markets exist, where a large number of buyers and sellers trade a single homogeneous product, and where the costs of holding inventories and transporting the product are not prohibitively high. (The importance of these conditions is illustrated by the case of GNMA vs. regular mortgages. The creation of GNMA mortgages served to homogenize the product and enable the establishment of both spot and future markets. See Froewiss, 1978.) These requirements are most applicable to financial assets. A large number of secondary markets have been organized for trading in stocks and bonds, and there are also organized markets—foreign exchange markets—for the buying and selling of national currencies. There are also auction-type markets for certain goods, primarily raw commodities such as wheat and soy beans. In general, however, most assets are traded on organized auction-type markets while most goods and services are not.

12. Adjustment lags for most goods prices are frequently attributed to the existence of fixed purchase-and-sale contracts. The existence of contracts per se does not cause these adjustment lags; after all, bonds represent fixed contracts also. Rather, the lags are due to the fact that these contracts are non-negotiable, i.e., no organized market exists for the purchase and sale of contracts for such goods.

13. Actually, a large enough change in one or two of these factors could reverse the sign(s), of the effects on the other factor(s), while still maintaining money-market equilibrium.

14. See Tucker (1971).

15. Equation 9 is a covered arbitrage condition only if ΔS^e is interpreted as log F − log S, where F is the forward exchange rate. Equation 9 then represents covered or closed interest parity. For this paper, we only assume that ΔS^e is the expected appreciation, log S^e − log S. If the forward rate is equal to the expected future spot rate then this will be a covered arbitrage condition, and if not equation 9 represents uncovered or open interest parity. See Frankel (1979) for a further discussion.

16. One additional short-run effect is not mentioned explicitly in the text. The permanent increase in the long-run expected inflation rate, and thus in the long-run interest rate, will cause a one-time reduction in the level of real money demand (due to movement along the money-demand curve). Thus, a permanent increase in the **rate of growth** of money will result in an additional one-time increase in the **level** of prices and a one-time decrease in the **level** of the exchange rate. To our knowledge, the quantitative importance of this effect has not been estimated.

17. For an example of an attempt to distinguish between anticipated and unanticipated money-supply changes see Barro (1978).

18. The relative magnitudes of expected and unexpected money changes for each country may be estimated roughly by examining the ranking of the means and variances of changes in excess-money ratios. The means give us an approximation of average expected excess-money growth over the estimation period, and the variances around the mean give us an approximation of unexpected excess money. We discovered, however, that the rankings of the means were approximately the same as the rankings of the variances—i. e., those countries with higher means also had higher variances of excess-money growth. Thus, the ranking of the unexpected relative to the unexpected remained indeterminate.

19. We calculated the change in excess-money supply in any month as equal to the change in nominal money supply in that month minus the change in the 36-month moving average in real balances. We used averages between 60 and 24 months for estimating the Japan/U.S. equations and the results were not sensitive to the length of the moving average, except at the short end.

20. Because of the lack of earlier data, the estimation period for the Japanese long-run interest equation was 75.02 to 78.12. Because of the closing of the Italian foreign-exchange market in February-March 1976, a dummy variable was used in the Italian price equation (equal to 1 in Mar./April 1976, and zero elsewhere) and in the Italian exchange-rate equation (equal to 1 in February-April 1976 and zero elsewhere).

21. In the text we focus on whether or not the coefficients in the price and exchange-rate equations are different from each other. While the two sum coefficients for each country are not statistically different from each other, a number of them are significantly different from one. Given the fundamental postulate of neutrality of money, how is it possible for monetary disturbances to have more than a proportionate effect (i.e., coefficients greater than one) on prices and exchange rates? Changes in the excess-money supply may perhaps be measured improperly, either because of an inappropriate definition of nominal money supply or because of an inappropriate measure of real money demand. Since money-supply data are available from standard statistical sources, and since money demand here is derived artificially as a 36-month moving average of the real money stock, the most likely source of error probably arises from the demand side. For example, current increases in money growth may generate expectations of similar future increases, and may therefore raise inflation expectations. This would cause people to economize on cash balances, i.e., reduce the quantity of money demanded. We have tried to account for this by using "excess money" instead of actual money, but our variable probably did not totally capture this effect. Consequently, we would expect the coefficients to be larger than one in both the exchange-rate and price equations. Pigott, in his article in this issue, discusses other reasons why these coefficients may be greater than one.

22. It was assumed for the t-test on the difference of the long run coefficients that this difference was normally distributed with variance estimated by the sum of the estimated variances of the coefficients minus twice their covariance. Their covariance was estimated by the correlation between the errors of the equations times the product of the estimated standard errors of the coefficients.

23. The French coefficient is significant only at the 90 percent confidence level.

24. Capital flows from France are subject to exchange-control approval, and are generally restricted. In the long run, most of the controls may be circumvented, but a complex system of administrative regulations still makes capital transactions very cumbersome. (See IMF, 1979.) This implies that adjustment of the exchange rate must occur through pressures which develop in the goods market rather than in the asset market. This is probably the reason why the French exchange rate adjusts at virtually the same speed as prices to a monetary disturbance, despite the existence of a liquidity effect in the short-term interest-rate equation.

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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-

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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,

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

or more commonly in change-form as

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

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:

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

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 δ( ).[27] In this, δ( ) 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 δ( ) 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 δ() 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,

$$p(t) = e(t) \tag{1}$$

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,

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

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:

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

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,

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

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

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

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,

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

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,

$$p_i(t) = \frac{1}{i} [m(t) + {}_tm^e(t+1) + \ldots {}_tm^e(t+i-1)] \equiv m^*(t) \quad (5)$$

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,

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

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*

Country	1957–1969 Percent Increase in Money Stock Level Expected After: 4 Qtrs	8 Qtrs	12 Qtrs	16 Qtrs	1970–1979 Percent Increase in Money Stock Level Expected After: 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*( ).

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Money, Inflation and Causality in the United States, 1959-79

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After more than twenty years of work on what has been called a "monetarist counter-revolution" to Keynesian economic thought,[1] the economics profession again has come to acknowledge the importance of the money supply in determining inflation and changes in nominal GNP. Most economists would agree that, in the long run, the level of the money supply has no sustained effects on output, but solely affects prices. Furthermore, most would also agree that non-monetary (cost-push) factors can have a sustained effect on the inflation rate only if they are accommodated or "validated" by increases in the money supply.

Given the widespread agreement on these points, the debate on the causes of inflation and the proper anti-inflation policy then revolves around the following issue: what factors have typically caused movements in the rate of money-supply growth. Inflation has continued and accelerated over the last fifteen to twenty years, as has growth in the money supply. What's more, it is generally agreed—and confirmed by existing evidence—that inflation could not have continued for this long without accompanying money-supply growth. It follows, then, that the underlying causes of inflation are those which can be convincingly shown to have caused money-supply growth—either directly or indirectly—over this period.

The present paper follows this argument by conducting tests of cost-push and government-spending theories of inflation. It applies the Granger causality-test technique to determine whether various "causes" of inflation have systematically caused, or been caused by, money-supply growth. These results then provide evidence as to whether the respective variables have indeed systematically caused recent U.S. inflation. Furthermore, we argue that this technique is indeed more powerful than those commonly applied to such theories.

The arguments for the possible effects of various inflation indicators on the money supply take many forms. With respect to the cost-push theory of inflation, many analysts argue that central banks are forced to expand money and credit in response to large cost increases in various industries in order to avoid the output losses and unemployment that would normally follow such phenomena. By "accommodating" such increases through monetary expansion, a slump is avoided, but at the cost of eventually higher inflation. These cost increases thus cause sustained inflation through their effect on the money supply. In the absence of accommodation, such increases primarily would cause changes in relative prices and temporary losses in output, but at most only temporary increases in the general price level.

As for the effects of government spending (deficits) on the money supply, analysts frequently argue that central banks monetize (accommodate) large government deficits rather than financing through tax increases or through government-debt issues which would raise interest rates. Though the monetization eventually leads to inflation, those favoring such an approach argue that this is politically prefera-

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ble to the alternatives, at least in the short-run.

The next section of this paper presents a short analysis of the theory underlying our approach. It discusses the necessity of accompanying money-supply growth in order to have continuing inflation, and therefore uses the "accommodation" hypothesis to substantiate cost-push theories of inflation. Section II applies the Granger causality test technique to U.S. data for the 1959-79 period, as a means of testing these accommodation hypotheses for various measures of cost-push or government-spending-based inflationary pressure. Section III analyzes the episodic evidence on the money-inflation relationship for two particularly prominent inflation periods: the post-oil-crisis period of 1974-75, and the recent 1978-79 period. Section IV concludes with a discussion of the implications of these results.

To summarize the results, we find virtually no evidence of monetary accommodation of cost-push or "supply shock" variables, despite testing over seventeen indicators of such pressures with respect to four measures of the money supply. In the majority of cases, the result indicates "one-way causality" emanating from several or all of the money-supply measures to the respective price or cost indicator. These results are especially prevalent with respect to wage and unit-labor-cost indicators. On the other hand, the results are less conclusive for government spending and deficit measures. Some of these indicators display causal effects on the money supply, but these results are either unsatisfactory in some way or are subject to conceptual problems involving the form of the equations themselves. The general tenor of these results remains the same when the estimation form for the respective relations is altered in different ways. In addition, previous and/or concurrent money-supply growth is found to provide a reasonable explanation of most of the inflation occurring in both 1974-75 and 1978-79.

I. Conceptual Issues Behind the Money-Price Interrelationship

To reiterate, most economists would agree that inflation cannot continue without an accompanying increase in the money supply. Inflation is essentially a tendency for all prices to continue to rise, with little or no attendant movements in workers, capital, or goods among industries. And only a change in monetary conditions, viz. an increase in the money supply, can plausibly generate such an increase in all prices with little or no side-effects on the real economy. Any other disturbance would change the prices of some goods relative to others—raising some, lowering others—and would therefore induce movements of resources among industries, but not necessarily any increase in prices in general. However, because economic actors can be expected to base their decisions on real conditions and on relative prices among goods, rather than solely on money prices, an increase in the supply of money (and thence in all money prices) leaves these real conditions and relative prices unchanged, and so results in a pure inflation.[2]

Many detailed discussions of this approach can be found in early post-war inflation surveys and early discussions of various types of cost-push or supply-side inflation theories—e.g., Schlesinger (1957), Haberler (1959), and Bronfenbrenner and Holzman (1963), the last of which lists many more such examples. This literature generally recognizes that in and of themselves, supply-side shocks are sources of only temporary inflationary pressure, and become sources of ongoing inflation only when they are accommodated by the monetary system.

This being the case, it's surprising that most empirical tests of supply-side inflation theories have completely ignored what Schlesinger calls "the monetary environment," and have instead attempted to identify statistical relations between the price level and the particular "causal" factor under consideration—e.g., Means (1935, 1972) and Wachtel and Adelsheim (1976). The problem with such tests is that positive results are then equally consistent with a wide variety of conflicting inflation theories.

For example, suppose a wage-push study

finds a relation between wage increases and inflation. This might signify the existence of wage-push. However, even in a monetary theory of inflation, increasing money supplies are considered to raise demand for goods and factors, and so to raise prices and wages. In such a theory, wages might be said to respond to money before prices, or the labor market might be considered part of the transmission mechanism whereby higher money supplies lead to higher goods prices. Either development then could imply a statistical relation between wages and prices. Thus, a relationship between wages and prices could exist under a number of theories, and so in and of itself, it provides no compelling evidence of the existence of wage-push pressure. Similarly for other indicators, without evidence regarding the effect of various factors on the "monetary environment," it's impossible to tell whether the existence of a statistical relation between inflation and a given indicator represents cause or effect: whether the indicator causes inflation, or whether money-supply growth causes both the indicator and the price level to rise.

Consequently, evidence on monetary accommodation is crucially important in identifying inflation's causes. Again, an increasing money supply is the one absolutely necessary symptom, the sine qua non, of any inflation. Holding milk prices frozen, or clothing prices, or even oil or auto prices, while allowing other inflationary phenomena to continue, would not materially change the nature of the inflation process. However, holding the money supply fixed, though letting other factors continue to rise, would soon bring any inflation to a sudden halt. Therefore, identifying some factor as a systematic cause of monetary expansion is the one reliable way to mark that factor as a cause of the inflation.

Yet very few studies have taken this approach in discussing the causes of inflation. Even monetary analyses have made little attempt to document the causes of monetary expansion as rigorously as they document the effects of money on prices. There are some exceptions, such as Gordon (1977), Bazdarich (1978), and various studies of Federal Reserve reaction functions, such as Barro (1979). Of these, only Gordon and Bazdarich attempt to identify causes of inflation, and then only with a very small number of variables for a number of countries.

The present study, in contrast, considers an exhaustive list of possible indicators of U.S. inflation. We perform Granger causality tests for these indicators to determine whether they can be identified as systematic causes of monetary expansion, and thence inflation. Now one might contend that monetary accommodation is typically an episodic process— that monetary authorities react to different factors at different times—and that tests for systematic effects are therefore likely to miss important effects. Yet we argue at length that systematic effects are necessary if we are to obtain objectively meaningful results, although we also analyze two major inflation episodes to illustrate the predictive power of various inflation theories over shorter periods of time.

II. Evidence of Systematic Accommodation

The Granger causality method, which we use here to test the various inflation theories, asserts that a variable x "Granger causes" a variable y if fluctuations in x can be used to predict subsequent movements in y, that is, if fluctuations in x are systematically transmitted to y. For example, consider the equation

$$y_t = \alpha + \sum_{j=1}^{n}\beta_j y_{t-j} + \sum_{j=1}^{m}\gamma_j x_{t-j} + \epsilon_{1t}, \qquad (1)$$

where x_t and y_t are values of x and y at time t, and where ϵ_{1t} is a random disturbance term. If the $(\gamma_1, \gamma_2, \ldots \gamma_m)$ vector is non-zero, then past x values can be used to predict current y values (even when the past history of y is considered as well through the $\beta_j y_{t-j}$ terms), so that x "Granger causes" y. Similarly, if, in the equation

$$x_t = \delta + \sum_{j=1}^{r}\eta_j x_{t-j} + \sum_{j=1}^{s}\mu_j y_{t-j} + \epsilon_{2t}, \qquad (2)$$

the $(\mu_1, \mu_2, \ldots, \mu_s)$ vector is non-zero, y is said to "Granger cause" x. When x "Granger causes" y, and y "Granger causes" x, two-way "feedback" exists between the variables. When x "Granger causes" y, but the converse doesn't hold, x is said to be econometrically exogenous to y—and similarly for the reverse.

On philosophical grounds, one would be hard pressed to assert that empirical evidence could be used to identify as metaphysical a concept as causality.[3] Thus the phrase "Granger cause" is substituted for "cause" in order to emphasize the philosophical shortcomings as well as the particular statistical phenomenon (that of predictive power) which is being identified. Still, it can be argued that the Granger-causality concept is quite relevant to our "causes of inflation" issues. In discussing the monetary accommodation issue, we cannot easily determine in what sense disturbances such as large wage settlements or oil-price increases truly cause the monetary system to expand credit. Rather, the issue is whether this process can systematically explain observed increases in the money supply, and the Granger technique would seem to be well suited for this purpose.

The existence of significant, positive causal effects from money-supply measures to inflation measures would tend to confirm the standard monetary analyses of inflation.[4] The existence of significant, positive causal effects from cost-push or government-spending indicators to money-supply indicators would indicate the existence of systematic monetary accommodation of these variables, so that they could indeed be deemed basic causes of inflation. These effects would have to be generally positive in order to show that the monetary authorities typically react to accommodate these factors, rather than perhaps countering them, which negative coefficients would suggest.

To estimate equations of the form in (1) and (2), one must choose finite values for the lag-lengths n, m, r, and s. Clearly, experimentation would allow one to find the values in each equation that best fit the data. However, such a procedure inevitably involves "peeking" at the data, and would inevitably affect the nature of the results. To avoid this problem, all tests were performed with a standard equation form using eight lags of each variable in equations (1) and (2).[5] The eight lags were considered sufficient to pick up the lagged effects of money on prices and wages, and vice versa. Following the initial tests, alternative estimation forms were also used.

Theoretical discussions of the Granger causality technique suggest the use of non-seasonally adjusted data, since seasonal-adjustment techniques can perhaps distort the statistical interrelation between two variables. We followed this approach as much as possible, adding seasonal dummies to pick up deterministic seasonality, while relying on the lagged dependent variables to prevent stochastic seasonality common to both variables from showing up as statistical causality.[6]

We performed our tests with quarterly data for the period 1957.1–1979.2, but dropped the first nine quarters from our sample period to generate lagged values and rates of change.[7] We used rates-of-change data to induce stationarity in the series, as well as for analytical reasons mentioned earlier.[8] We chose cost-push indicators which could represent specific effects, but still be general enough to be recognized—and perhaps reacted to—by the monetary authorities. We utilized four monetary aggregates—M-1 (currency plus bank demand deposits), M-2 (currency plus all bank deposits except large time certificates), the source base (sources of the monetary base as defined by the Federal Reserve Board of Governors), and the St. Louis base (the monetary base, adjusted for reserve requirement changes, as defined by the Federal Reserve Bank of St. Louis).[9] We calculated F-statistics to test the significance of each explanatory variable in "Granger causing" the respective dependent variable. A significant F-statistic indicates evidence of Granger causality for the explanatory variable in question— that is, it implies that the γ-vector in forms of equation (1), or the μ-vector in equation (2), is significantly different from a zero vector.

In testing our money-price relation, the F-statistic of 2.9 represents an effect of M-1 on the consumer-price index that is significant at the 1-percent level (Table 1, line 1). The long-run effect of 1.6 indicates that any sustained one-percentage-point change in the M-1 growth rate would generally eventually result in a 1.6-percentage-point change in the CPI inflation rate in the same direction.[10] The F-statistic of 2.6 indicates an effect of CPI inflation on M-1 growth that is significant at the 5-percent level, while the long-run effect of 0.1 indicates that a one-percentage-point change in the CPI inflation rate would eventually result in a 0.1-percentage-point change in the M-1 growth rate. The results for the other monetary indicators and the CPI can be equivalently interpreted.

All four monetary indicators have effects on the CPI with some degree of significance, as monetary theories would lead one to expect. On the other hand, the CPI has significant effects only on M-1 and M-2. This by itself need not be damaging to an accommodation hypothesis, since it could be argued that accommodation should show up in the Federal Reserve's traditional policy variables, M-1 and M-2, rather than in variables which the Fed targets only indirectly, such as the monetary-base indicators. (Even so, such accommodation, if significant, should be expected to show up to some extent in the base indicators, which are certainly affected by Fed open-market operations). Nevertheless, a more serious problem with interpreting the significant effect of the CPI on M-1 and M-2 as evidence of accommodation is that the signs of the significant coefficients for the CPI effects are negative at the shorter lags, and become positive only at the longer lags. In other words, the equations suggest that given a disturbance to CPI inflation, the Fed initially acts to counter rather than accommodate this disturbance, while its estimated reaction becomes and stays positive only after a substantial lag (twenty-five quarters!), and even then only at an insignificant level. Thus, despite the significant effects of the CPI on M-1 and M-2, the tests involving that variable do not show much sign of systematic accommodation by the Fed.

Much the same is true for other consumer-price variables. Most of the monetary indicators have significant effects on consumer food prices and the CPI excluding food. Significant reverse effects are shown only for the CPI excluding food on M-1. In this case, as seen already with the entire CPI on M-1 and M-2, the effects at the shorter lags are negative, with the estimated equation showing no real sign of accommodative tendencies by the Fed. For the GNP price deflators—for both total GNP and personal consumption—the results generally display strong one-way causality from the money-supply variables to the price indices, with no sign of systematic monetary accommodation.

The wholesale (producer) price variables similarly show no sign of accommodation. Virtually all are significantly affected by M-1 and various other monetary indicators. Yet, significant reverse effects are shown only from steel and metals prices onto M-2. Here again, the long-run effects of these variables on M-2 are small and likely insignificant. Also, these variables show no significant effects on M-1, which in the past two decades has surely been a more prominent indicator of Fed policy than M-2. In fact, the effects of steel and metals prices on M-2—in the absence of effects on M-1— may reflect business-cycle factors. Metals and steel prices are very cyclically sensitive. Similarly, because disintermediation in times of cyclically high interest rates normally affects M-2 more than M-1, it would appear that a large portion of disparate movements between M-1 and M-2 would reflect cyclical factors. Thus, the estimated relationship between M-2 and steel and metals prices (and the lack of such a relation for M-1) may reflect the existence of similar cyclical behavior in these variables.

As for labor-market indicators, we see absolutely no sign of accommodation effects on any of the monetary indicators of movements in either wages or unit labor costs (Table 1). Unit-labor-cost data are available only in seasonally adjusted form, so that those particular results should be interpreted with caution, but the results are completely consistent with those for the wage data. The general result indicates

Table 1
Causality Results Between Various Economic Indicators and the Monetary Aggregates
Eight Lags for all Variables, 1959.2–1979.2*

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]
All Items	2.9***	1.6	2.6**	0.1	2.1**	1.4	2.4**	0.4	1.7*	1.1	0.9	0.1	2.2**	0.9	1.2	0.0
Food	2.6**	1.9	1.6	−0.1	2.2**	1.5	1.6	0.2	2.4**	1.2	1.0	−0.1	1.5	0.9	1.1	0.0
Excluding food	1.7	1.7	3.3***	0.3	1.2	1.7	1.5	0.4	1.8*	1.2	0.9	−0.2	2.1**	0.9	1.3	−0.2
Wholesale Prices																
All Items	2.8***	2.3	0.6	−0.3	2.2**	1.9	0.9	0.2	1.1	1.5	0.3	0.0	2.2**	1.1	0.8	−0.2
Non-Farm	1.9*	2.2	0.8	−0.1	1.6	1.9	1.5	0.2	0.9	1.4	0.4	0.0	3.0***	1.2	0.7	−0.4
Farm	2.4**	2.4	0.5	−0.4	1.5	2.0	0.7	0.1	1.4	1.5	0.3	0.0	1.8*	0.9	0.7	0.1
Metals	2.4**	2.4	0.9	−0.1	1.4	1.9	2.3**	0.1	1.9*	1.5	1.6	0.0	2.5**	1.4	0.7	−0.5
Steel	1.2	2.4	1.6	0.1	1.0	1.7	2.8**	0.1	1.5	1.6	0.9	0.0	2.0*	1.4	0.6	−0.5
Fuel	2.3**	3.8	0.7	0.0	1.6	3.1	1.0	0.1	1.9*	2.7	0.7	0.1	1.7	2.7	0.9	−0.2
Petroleum	2.1**	3.1	0.8	−0.1	1.1	2.0	1.0	0.1	1.1	1.9	0.4	0.1	1.4	1.9	0.6	−0.4
Wages for																
Nonagricultural Workers[3]	2.5**	0.5	0.7	0.4	2.4**	0.4	0.6	0.2	3.8***	0.5	1.0	0.7	3.9***	−1.4	0.7	0.5
Manufacturing	1.2	1.5	0.7	0.5	2.3**	1.5	1.1	0.5	3.9***	1.1	0.9	0.1	3.7***	1.1	1.0	0.2
Unit Labor Costs																
Private Business	2.7**	1.6	0.8	0.3	1.7	1.3	1.0	0.5	1.4	1.1	0.7	0.3	2.4**	1.0	0.2	−0.7
Manufacturing	1.7	1.6	0.4	0.1	1.4	1.1	0.8	0.2	1.3	0.8	0.9	0.1	1.8*	0.9	0.6	−0.7
Non-farm	2.7**	1.6	0.4	0.3	1.7	1.3	0.7	0.4	1.8*	1.1	0.9	0.2	2.0*	0.9	0.3	−0.7
Unemployment Rates																
All Workers[4]	3.2***	1.3	0.6	0.2	1.4	−0.3	1.2	0.2	1.5	0.6	1.9	0.3	0.8	0.4	0.4	0.1
Males 25-44[4]	3.5***	0.7	0.4	0.0	2.1**	−0.7	1.3	0.1	1.8*	−0.2	0.9	0.2	0.2	0.0	0.8	−0.1
Implicit Deflators																
GNP	3.2***	1.3	1.1	0.5	2.3**	1.1	1.1	0.6	2.7**	1.0	1.0	0.4	1.6	0.9	2.0*	−0.6
Personal Consumption Expenditures	2.4**	1.3	1.0	0.4	2.6**	1.2	1.2	0.5	1.7	1.0	0.8	0.3	2.2**	0.8	0.9	−1.0
Government Deficit[5]	1.7*	5.0	2.3**	0.1	0.5	2.2	1.8*	0.2	0.7	16.6	1.2	0.1	1.8*	15.0	2.0*	0.1
Deficit/GNP Ratio[4,6]	0.8	0.1	0.6	0.4	1.1	0.4	0.6	0.2	0.7	0.8	0.6	0.1	1.1	0.7	1.1	0.5
Government Spending[6]	0.8	0.7	1.4	0.1	0.5	0.6	2.5**	0.2	1.0	0.7	0.7	−0.2	1.0	0.7	0.9	0.4

*First column of each set shows F-statistic for effect of respective monetary aggregate on "cost" variable; second column shows long-run effect for this relation; third column shows F-statistic for effect of "cost" variable on respective monetary aggregate; fourth column shows long-run effect for this relation.
*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.
[1]F-Statistic for hypothesis that explanatory variable has no effect.
[2]Long-run effect of a permanent one-percentage-point change in explanatory variable on dependent variables; see Appendix 1.
[3]Sample period: 1966.2–1979.2.
[4]"Cost" variable is in level form.
[5]Level of deficit vs. first difference of supply.
[6]Sample period: 1959:2–1978:4.

one-way causality from the monetary indicators to the labor-market indicators.

Haberler has suggested that central banks typically react more to unemployment rates than wages, and that wage increases exert sustained effects on inflation by initially raising unemployment, which the authorities then counter by monetary expansion.[11] Thus, he postulates a causal chain—from wages or labor costs to unemployment to monetary expansion to inflation. If this were in fact the case, one would still expect wages or labor costs to affect monetary expansion, although at perhaps long lags because of the two-step process. However, we have seen that this is not the case. We also tested this hypothesis directly by running causality tests between labor-cost variables and unemployment, and between unemployment rates and the money-supply indicators. Though two-way causality or feedback was found between the labor-cost variables and unemployment rates, one-way causality from money-supply growth to the unemployment rates was generally found, with no sign of "accommodation" of unemployment forthcoming. Thus, the feedback between wages (or labor costs) and unemployment is consistent with the apparent one-way causal effects of money-supply movements on all of these variables. Although wages or labor costs are usually cited prominently in cost-push analyses of inflation, our analysis found no sign of systematic effects of these variables on the "monetary environment," and so no compelling evidence for these variables as causes of sustained inflation.

Most of the tests for cost-push indicators involved price indices vis-a-vis money-stock variables, so that the *percentage rate of change* of each of the variables in a particular set could be readily related in theoretical terms as well as providing reasonably stationary time series. That is, a change in the percentage rate of growth of say, M-1 could be expected to elicit essentially the same percentage-point change in, say, the CPI inflation rate, and vice versa—no matter how high or low these rates were. Thus, equations (1) and (2) could reasonably be expected to be stable over time for these variables, and could be expected to yield statistically meaningful results.

However, we should not expect the same for various government spending or deficit variables. The government deficit, in its raw form, is measured in dollars, and so should have an increasing trend over time, both because of inflation and economic growth. Therefore it should be non-stationary. The percentage rate of change of the deficit is not a reliable indicator either, since a change from a $1 deficit to a $2 deficit need not elicit the same money-supply change as a shift from a $10-billion to a $20-billion deficit, and since any change from a balanced budget indicates an infinite percentage change.

One alternative is to run the test between the level of the deficit and the first difference in the particular money-supply variable. This equation form implies that a given dollar amount of deficit requires a given dollar amount of monetization by the Fed, and so a given dollar amount of change in the money-supply indicator. This form, although consistent with government-deficit theories of inflation, has poor statistical properties because both of the variables are non-stationary. Despite these reservations, we ran causality tests using this equation form,[12] and found significant effects of the deficit on money growth, with significant positive coefficients at the shorter but not at the longer lags.[13] But again, given the suspect nature of the variables, these results must be interpreted carefully.

Another alternative would be to induce stationarity in the deficit series by dividing it by another series with similar trend, such as nominal GNP. Such a ratio does not have dollar dimensions, and so will not be non-stationary on this count. However, the resultant equation form does not have clear theoretical validity—thus, a one-point change in the deficit as a percentage of nominal GNP need not generally elicit a fixed change in the money-supply growth rate. When we performed causality tests between the deficit/nominal GNP ratio and various money-supply growth rates, we found no significant effects in either direction.

Table 2
Causality Results Between Various Economic Indicators and the Monetary Aggregates
Four Lags for all Variables, 1959.2–1979.2

	M-1				M-2				St. Louis Base				Source Base			
	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]
Consumer Prices																
All Items	2.5**	1.9	1.7	0.2	1.3	1.7	1.9	0.3	1.8	1.3	1.0	0.3	2.8**	1.1	1.0	0.3
Food	3.6***	1.8	1.3	0.1	1.8	1.3	1.0	0.1	2.0*	1.3	0.4	0.2	1.4	0.8	1.3	0.3
Excluding Food	1.6	1.6	1.3	0.3	1.9	1.5	1.2	0.3	3.3**	1.3	0.5	0.2	3.9***	1.3	0.3	0.0
Wholesale Prices																
All Items	2.7**	2.2	0.1	0.0	1.5	1.7	0.2	0.1	1.4	1.5	0.2	0.1	1.8	1.2	0.4	0.1
Non-farm	1.7	1.8	0.4	0.0	1.1	1.4	0.3	0.1	1.3	1.4	0.3	−0.1	1.5	1.2	0.3	−0.1
Farm	2.7**	2.2	0.2	0.0	1.2	1.4	0.5	0.0	1.5	1.5	0.2	0.0	1.2	0.9	1.0	0.2
Metals	2.0*	1.9	1.5	0.1	1.8	1.4	2.9**	0.1	3.9***	1.4	1.3	0.1	2.5**	1.3	0.8	−0.2
Steel	1.6	1.7	0.7	0.1	2.2*	1.3	1.8	0.1	2.1*	1.5	0.6	0.1	2.5**	1.5	1.0	−0.2
Fuel	1.4	1.8	0.1	0.0	0.9	1.0	0.5	0.1	1.5	2.4	0.5	0.1	1.4	2.5	0.6	−0.1
Petroleum	1.2	1.3	0.8	0.1	0.4	0.1	1.4	0.1	0.2	1.0	0.6	0.1	1.3	2.2	0.4	−0.1
Wages for																
Nonagricultural Workers[3]	4.1***	0.5	0.3	0.3	3.7**	0.2	0.3	0.0	6.2***	0.5	0.2	0.4	1.4	0.2	0.1	0.2
Manufacturing	1.6	0.9	0.9	0.5	3.6***	0.8	1.6	0.4	4.8***	0.9	1.0	0.4	3.2**	0.7	1.2	0.2
Unit Labor Costs																
Private Business	4.1***	1.5	0.4	0.2	2.0	1.0	0.8	0.3	2.2*	1.0	0.6	0.2	3.6***	0.9	0.3	−0.1
Manufacturing	2.3*	1.2	0.3	0.1	1.7	0.5	0.7	0.2	1.5	0.7	0.8	0.2	2.7**	0.9	0.7	−0.2
Non-farm	3.6***	1.5	0.3	0.2	1.8	1.0	0.9	0.3	1.9	1.0	0.8	0.3	2.9**	1.0	0.7	−0.1
Unemployment Rates																
All workers[4]	0.9	−0.9	0.5	0.1	1.4	−1.4	1.2	0.2	0.4	−0.1	1.1	0.2	0.1	0.4	0.4	0.1
Males 25–44[4]	2.8**	−0.8	0.3	−0.1	2.8**	−1.2	2.0	0.0	0.5	−0.5	0.5	0.0	0.4	0.1	1.2	−0.1
Implicit Deflators																
GNP	3.2**	1.3	1.0	0.3	1.8	1.0	1.4	0.4	3.1**	1.0	1.2	0.3	3.2**	0.9	3.3**	0.2
Personal Consumption Expenditures	2.7**	1.2	0.4	0.3	1.6	1.0	1.2	0.4	2.9**	1.0	0.5	0.3	3.6**	0.3	0.7	0.0
Government Deficit[5]	0.1	−2.7	1.9	0.1	0.2	1.5	2.3*	0.2	0.9	12.4	1.0	0.0	2.5**	11.9	2.4*	0.0
Deficit/ GNP Ratio[4,6]	1.2	−0.7	0.7	0.2	1.1	0.2	0.6	0.2	1.6	0.9	0.3	0.2	1.6	0.5	1.0	0.5
Government Spending[6]	0.2	0.0	0.6	0.2	0.2	0.3	2.7**	0.3	1.1	0.5	0.6	0.2	0.9	0.7	0.9	0.3

*First column of each set shows F-statistic for effect of respective monetary aggregate on "cost" variable; second column shows long-run effect for this relation; third column shows F-statistic for effect of "cost" variable on respective monetary aggregate; fourth column shows long-run effect for this relation.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level.

[1]F-Statistic for hypothesis that explanatory variable has no effect.

[2]Long-run effect of a permanent one-percentage-point change in explanatory variable on dependent variables; see Appendix 1.

[3]Sample period: 1966.2–1979.2.

[4]"Cost" variable is in level form.

[5]Level of deficit vs. first difference of supply.

[6]Sample period: 1959:2–1978:4.

One other alternative would be to consider the percentage rate of change in government debt, since the deficit presumably represents the first difference in the debt. But there is no reason why a stable relation should exist between the rates of change in debt and money stock. Additionally, several measures of the government debt, including on- and off-budget items and various agency-debt issues, do not provide first differences comparable to the deficit. We found no significant results when running tests using some of these variables.

Finally, we might consider government spending as a cause of inflation and money growth, since it represents the government's actual drain of goods and services from the economy—and since spending changes should correspond to deficit changes, given the largely inflexible (short-term) nature of the tax codes. Also, the percentage rate of change of government spending makes statistical sense and is likely to be stationary. However, our tests indicate that none of the money-supply variables have significant effects on government expenditures. Expenditures have a significant effect on M-2, and also have a significant effect on M-1 when data for an earlier time period are included. Even for these results, however, the coefficients of expenditures at shorter lags are negative, which would suggest that accelerations in spending are initially followed by decelerations in money growth. Obviously this finding is counter to what government spending-inflation theories normally suggest.

One might argue that our eight-quarter lag structures are not conducive to measuring accommodation effectively, that perhaps shorter lags would be better for that purpose, since if the Fed acts to accommodate inflationary disturbances, it might do so quickly in order to avoid near-term losses in output and employment. We tested this thesis by re-estimating our Table 1 equations using four-quarter lag structures (i.e., $n = m = r = s = 4$ in equations [1] and [2]), with the results shown in Table 2.

However, there is even less evidence of accommodation with these shorter lag structures. The significant effects of the CPI on M-1 and M-2 disappear, as do the effects of steel prices on M-2. The only significant "feedback" onto monetary indicators occurs for metals prices on M-2, the GNP deflator on the source base, and the deficit on M-2 and the source base. In view of the isolated nature of these results, and in view of the mitigating factors discussed for similar results in Table 1, the feedback shown in these three cases can probably be dismissed as evidence of accommodation. With our re-estimated equations, the significance of the effects of money on prices and wages also declines slightly, but the general result is still that of one-way causality from money to inflation indicators. There is certainly nothing in these results that gives any stronger signal of accommodation than the very weak evidence found with longer lag structures. We also obtained similar results with tests involving Almon polynomial-lag structures, and with tests involving smaller sample periods (see Appendix).

Conceivably we could keep dropping or adding coefficients and re-estimating equations until we found "significant" positive effects of some inflation indicator on some money-supply indicator. But after mining the data in this fashion, it would be impossible to determine whether the significance of the results actually lay in the data or in the prior beliefs of the experimenter.

For the present results, we used general-equation forms to minimize the amount of prior information that might affect the results. These tests were generally able to verify the existence of a strong effect of monetary expansion on a wide range of inflation indicators, but found no reliable accommodative effects of these indicators on the money-supply process. Thus the evidence suggests that cost-push factors do not provide a convincing explanation of continuing inflation in recent U.S. history. Much the same could be said of government-spending theories of inflation, although our equation forms were not as well suited to these types of theories as they were to cost-push theories. Also, these indicators showed more positive results, although their reliability was suspect.

III. Episodic Evidence on Inflation

Our tests found no reliable sign of systematic accommodation by the monetary authorities of cost-push or supply-side inflationary pressures. It might be argued that the tests were run over too long a time period to obtain meaningful results—that the Fed's "reaction function" for these disturbances varies or evolves over time, and/or that the Fed reacts to different factors at different times, so that a test involving one such factor over a twenty-year period is doomed to failure. However, these arguments for shifting, evanescent effects hamper the measurement of such phenomena, and also diminish the usefulness of the theory which they are intended to support.

If a theory is to be objectively testable and useful for practical purposes, it must hold over an extended period of time. To see this, recall that in our tests, we estimated a common equation form, and avoided the temptation to "doctor" the equations to improve the results. We did this not because of an unshakable belief in the equation form we used, but in order to make the data speak directly to us and thus to avoid making any subsequent changes that would inevitably bring subjective judgment into the final results.

By the same token, to argue that monetary policy reacted to, say, wages in 1957-58, and then to use 1957-58 data to "verify" this argument, inevitably involves prior knowledge of the data. This argument also effectively ignores prior historical events (perhaps inflationary money growth in 1955-56) that might better explain 1957-58 developments. We would be dealing with a sample of one period, i.e. the 1957-58 period, which was drawn from the whole set of historical data in a non-random way. It is difficult to determine the reliability of any such demonstration unless the evidence holds over an extended period of time. Also, tests over such a narrowly specified period could provide evidence of an effect only for that period. Knowing that money growth and inflation, say, in 1957-58 were caused by wage increases would not necessarily tell us anything about the causes of inflation in other periods.

A verifiable, useful hypothesis about monetary accommodation and inflation therefore should be supported by evidence of a systematic link between the particular variable and the money supply over a period of time long enough to allow statistical identification. Although we were unable to find that type of evidence in our earlier analysis, it is nevertheless interesting to examine the explanatory power of the competing theories in certain specific periods.

Consider first the 1973-75 inflation. This burst of inflation followed three possible causative factors: the removal of mandatory wage and price controls, largely completed by late 1973; the oil crisis in late 1973, which resulted in a quadrupling of crude oil prices; and a worldwide acceleration in money-supply growth starting in late 1970.[14] The removal of wage and price controls could be expected to precipitate a temporary acceleration in inflation in 1973-74 to make up for the 1971-73 suppression of inflation, therefore transfering it to the period immediately following the removal of controls. The oil-price shock, on the other hand, could have caused a temporary acceleration in inflation for reasons discussed earlier.

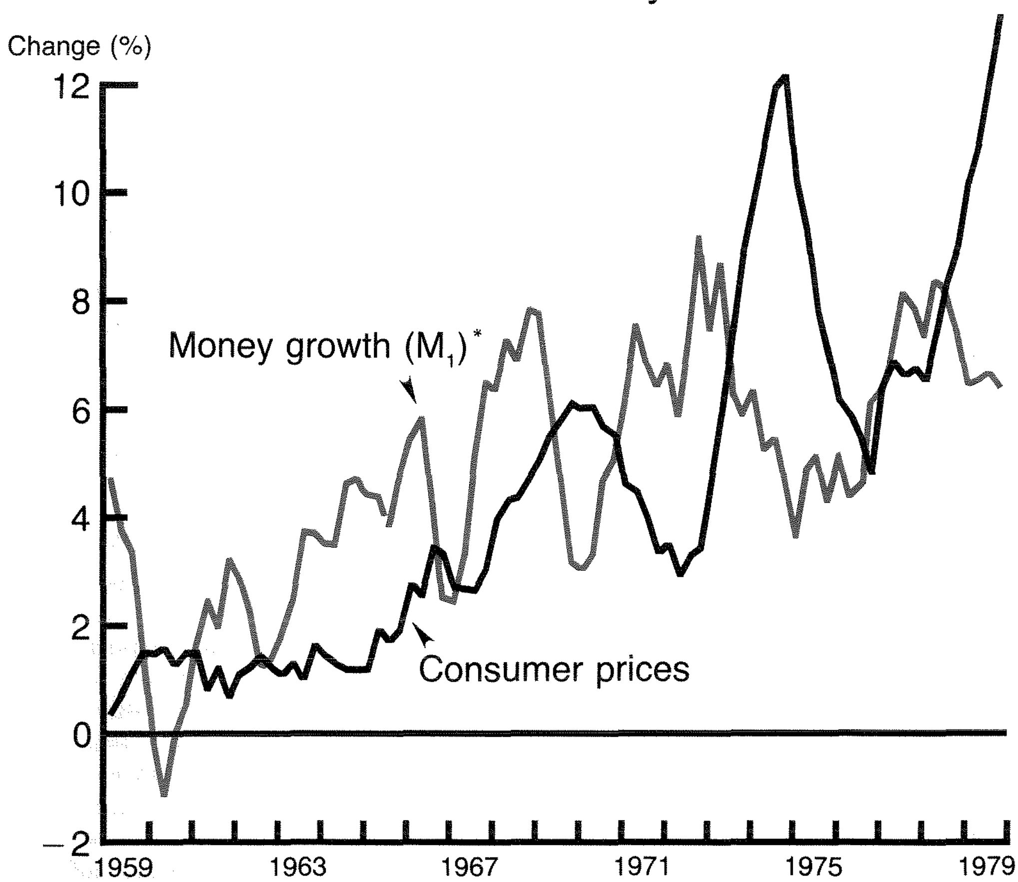
In any event, monetary accommodation was not evident in 1973-74, because money-supply growth was decelerated sharply both before and after these several developments (Figure 1).[15] The Federal Reserve apparently moved to counter—rather than accommodate—inflationary forces following the removal of controls and the oil-price shock. Therefore, on the basis of our earlier analysis, none of these factors could be regarded as sources of continuing inflation even in this subperiod.

This leaves the question: how important are these factors as causes of transitory inflation over the period at hand? We can address this question by determining how much inflation can be explained by monetary forces alone, attributing any remaining inflation to the non-monetary factors mentioned. Because the existence of controls probably shifted monetary inflation to the post-controls period, the simulations were performed starting in third-quarter 1971, the date of imposition of the controls. Because the suppressed inflation presumably took two years to work through the economy, the simulation period was terminated in fourth-quarter 1975, two years after the end of the controls period.[16]

Thus, the inflation-money version of equation (1) was simulated over 1971.3-1975.4 for four general measures of inflation (CPI, WPI, GNP deflator, and GNP deflator for personal consumption goods) and for the four basic money-supply measures.[17] Because the results could be biased by using an equation form estimated from a sample period including 1971.3-1975.4, we performed simulations for equations estimated from two other sample periods: 1959.2-1971.2, designated the "short" sample period, and 1959.2-1971.2 /1976.1-1979.2, designated the "bracketed" sample.

As would be expected, the simulations yielded generally positive "forecast" errors over the early part of the period, when controls should have suppressed inflation below the level implied by previous money-supply growth, and generally negative "forecast" errors over the latter period, when the removal of controls should have pushed inflation above levels predicted by previous money-supply growth. Yet the monetary aggregates do a

Chart 1
Inflation and Money Growth



*Adjusted for automatic transfer accounts (ATS) fairly good job of explaining cumulative inflation over the entire period (Table 3). M-1 growth can explain all but 6 percentage points of the 37.9-percent cumulative increase in the CPI in the short-sample simulation, and actually overpredicts inflation in the other simulations. Similar results hold for the deflator simulations. In contrast, simulation errors are larger by as much as 31 percentage points for the 56.2-percent cumulative increase in the WPI. The disparity can be explained in part by the fact that the WPI involves goods at all stages of the production process, and so probably over-counts the effects of an increase in the price of a factor (like oil) which is prominently used in a number of products. Also, as our earlier analysis suggests, a supply shock should primarily affect relative prices. In the case of the oil shock, one would expect the relative returns to other productive factors, such as labor and capital, to fall relative to that for energy. This would then increase the level of wholesale prices relative to consumer (retail) prices, since the latter has a higher service and labor content, while the former is more sensitive to fuels and primary products.

In any case, previous movements in money-supply growth (along with the transferring effects of controls) are able to explain most of the 1973-75 inflation, with the divergent movements between the WPI and the other measures apparently due to higher relative prices for oil and energy inputs. These results, and the apparent lack of monetary accommodation of various price shocks, suggest that this period was not demonstrably different from other periods in terms of the interrelation between monetary policy and inflation.

In similar fashion to the earlier debate, some analysts today describe the 1978-80 inflation as being a new strain of the inflationary "virus," contracted from different "germs," and so somehow immune to traditional anti-inflation policy prescriptions. They tend to blame the current inflation on large food-price increases in early 1978, and oil-price increases in 1979, spread through the economy by workers seeking to index their wages to the cost of living. Some argue that this widespread trend to indexing makes inflation more immune to restrictive monetary policy. Still, the arguments propounded today resemble those made in 1973-75, although perhaps on a smaller scale.

We can gain some insight into the nature of

Table 3
Simulation of Money-Inflation Effect, 1971.3–1975.4

Inflation Indicator	Actual Inflation Over Period	Inflation Forecasted (and Forecast Error) By			
		M-1	M-2	St. Louis Base	Source Base
		Short Sample			
Consumer Price Index	36.9	29.2 (5.9)	33.8 (2.3)	26.1 (8.5)	21.0 (13.1)
Wholesale Price Index	56.2	19.3 (31.0)	24.4 (25.5)	23.4 (26.6)	17.3 (33.2)
GNP Deflator	35.9	38.2 (−1.6)	56.1 (−14.8)	40.6 (−3.4)	35.9 (0.0)
Personal Consumption Deflator	34.3	26.6 (6.1)	34.3 (0.1)	25.5 (7.0)	23.4 (8.9)
		Bracketed Sample			
Consumer Price Index	36.9	38.8 (−1.4)	41.8 (−3.6)	36.6 (0.2)	33.6 (2.5)
Wholesale Price Index	56.2	34.5 (16.1)	37.4 (13.7)	35.6 (15.2)	31.0 (19.3)
GNP Deflator	35.9	33.8 (1.6)	39.6 (−2.7)	35.3 (0.5)	31.2 (3.6)
Personal Consumption Deflator	34.3	32.4 (1.5)	40.8 (−4.8)	33.2 (0.8)	28.5 (4.5)
		Long Sample			
Consumer Price Index	36.9	38.5 (−1.2)	37.4 (−0.4)	34.8 (1.6)	31.0 (4.4)
Wholesale Price Index	56.2	44.8 (7.9)	43.6 (8.8)	41.1 (10.7)	32.8 (17.6)
GNP Deflator	35.9	35.6 (0.3)	34.8 (0.8)	33.1 (2.2)	32.0 (3.0)
Personal Consumption Deflator	34.3	33.2 (0.9)	32.0 (1.7)	31.2 (2.4)	27.7 (5.2)

this inflation by analyzing it in terms of the money-price relations developed earlier. Money-supply growth started to accelerate in late 1975 or early 1976, following two years of declining growth rates. (Figure 1). This development would suggest an acceleration in inflation starting in late 1976 or early 1977, and becoming very strong by about early 1978, as actually occurred. However, there were no signs of an acceleration in labor costs, nor any identifiable supply shocks, at the time of the monetary acceleration. It seems unlikely, then, that the monetary acceleration of 1976-77 was generated by accommodative Federal Reserve behavior, at least attributable to cost-push pressures.

To measure these factors more precisely, we again simulated the inflation-money supply equations for various indicators. To avoid biasing the results, we again re-estimated the equations over sample periods not including the respective simulation period. Thus, the equations were estimated over the 1959.2-1977.4 period, and simulated over 1978.1-1981.4 (first simulation), then estimated over 1959.2-1978.4 and simulated over 1979.1-1981.4 (second simulation), and finally estimated over 1959.2-1979.4 and simulated over 1980.1-1981.4.[18]

Despite the correct "phasing" evidenced in recent years between money growth and inflation, significant amounts of inflation clearly appeared to be outside the explanation of previous money-supply growth (Table 4). For example, CPI inflation was two percentage points higher in 1978 and four percentage points higher in 1979 than would be suggested by conditional forecasts based on M-1 growth.[19] These results would seem to reflect the impact of the 1978 food-price shock and the 1979 oil-price shock. Even so, the first simulation results are still able to explain a large part of the recent inflation acceleration.

To the extent that large, recognizable shocks to food and oil prices explain the rest, this argument is consistent with the previous analysis, where such shocks were said to have possibly permanent effects on the price level (independently of the money supply) and so temporary effects on the inflation rate. However, this can be true only to the extent that the simulation errors evidenced in Table 4 represent the effects of unforseeable shocks. If these errors could be attributed instead to the systematic effects of factors predictable on non-monetary grounds, the power of the money-price relation might be diminished. To analyze such questions, we should consider what forecasters were predicting about 1978-79 inflation in 1977-78. These analysts, especially those employing large econometric

Table 4
Simulations of M-1 Inflation Equation (1978–81)
Compared to Forecasts By Major Analysts

Consumer Price Index		Simulation Results Over Sample Period			Forecasts By: Wharton Econometrics			Data Resources Inc.			Time Magazine Board of Economists
	Actual	59.2–77.4	59.2–78.4	59.2–79.4	12/31/77	12/1/78	12/3/79	12/21/77	12/27/78	12/20/79	
1978	9.0	7.0	—	—	5.5	—	—	5.8	—	—	6.2[1]
1979	13.3	8.0	9.0	—	6.3	7.1	—	5.3	7.8	—	7.5[1]
1980	—	7.9	8.1	11.8	—	6.3	11.3	5.7	6.9	10.4	9.1[1]
1981	—	6.4	6.1	7.9	—	—	8.7	—	6.8	9.1	
GNP Deflator											
1978	8.2	6.5	—	—	5.6	—	—	6.0	—	—	—
1979	8.9	7.7	8.8	—	5.7	6.6	—	5.4	7.4	—	—
1980	—	7.8	8.3	8.8	—	6.1	9.4	6.1	7.1	9.4	—
1981	—	6.8	7.1	7.2	—	—	7.8	—	6.9	9.2	—

[1]This rate is the December over previous December increase.

models, presumably utilized a wide range of available information in their forecasts. If our simulations compare favorably to their forecasts, it would suggest that recent "nonmonetary" inflation was in fact due to large unforseeable shocks to oil and food prices rather than to systematic defects in the money-price relation.[20]

As it turns out, most analysts experienced forecast errors larger—and in some cases much larger— than the errors for the money-price simulations shown in Table 4. Most late-1978 forecasts showed inflation slowing to below 8 percent in 1979. The simulations—using money-supply information through 1979 but price information through only 1977 or 1978—showed inflation remaining steady or even accelerating in 1979. Despite underpredicting 1979 CPI inflation by four percentage points, the simulation predictions were certainly more accurate than those of the major forecasters.

This does not necessarily mean that the money-price equation is a superior forecasting tool, because the simulations utilized information not available to the forecasters: actual-money-supply growth over the respective simulation periods.[21] However, it does suggest three important points: a) actual money-supply growth is indeed helpful for predicting inflation in the present period; b) the large errors, apparent in both the simulations and outside forecasts, represent the effects of random, unpredictable shocks, rather than systematic defects in the money-price relation; and c) M-1 does a creditable job of explaining inflation in 1978-79, accounting for an acceleration in the underlying rate of inflation to the 8-to-10 percent range.

The remaining CPI inflation in 1979 is clearly due to the short-term effects of large oil-price increases, given the larger errors experienced by forecasters using more structural information—and given the lack of large simulation errors for the GNP deflator, which does not directly include import prices, and thus fails to reflect the full impact of OPEC price actions. Such a random shock to prices can temporarily pull measured inflation rates away from rates predicted by the money supply. However, the expansion in money-supply growth and the acceleration in inflation clearly occurred well before oil prices surged, so that the recent inflation could not be attributed to monetary accommodation of oil-price increases.

In summary, the 1973-75 and 1978-79 episodes of inflation did not show any greater sign of accommodation than did the 1959-79 period as a whole. In each case, the acceleration in inflation was preceded by an acceleration in money-supply growth. The money-supply behavior then was able to explain a predominant portion of actual measured inflation, with the remaining part clearly attributable to the temporary effects of oil- and food-price shocks. As for 1980, the money-price relation suggests that inflation, though declining, will remain quite high through the year, even if M-1 grows no faster than the 5-percent rate assumed in the simulations.

IV. Summary and Conclusions

In this article, we have examined the direction of Granger (econometric) causality between the U.S. money supply—as measured by four prominent monetary aggregates—and a number of variables considered representative of cost-push and government-deficit inflationary pressures. We found widespread and significant "causal" effects from the money-supply measures to the price or cost variables, but found no reverse effects, at least not of a nature that would suggest monetary-accommodation. Thus, we found little if any evidence of the systematic existence of cost-push inflation in the last twenty years. Furthermore, even in two recent episodes of inflation acceleration, the behavior of the money-supply measures alone was capable of explaining these experiences reasonably well, with little evidence of accommodation. Though some signs of systematic effects of government-spending variables on the money supply existed, these effects were not particularly convincing.

These results therefore fail to support the commonly-held theory of a wage-price spiral: the idea that increasing labor costs cause increasing prices, which cause workers to seek still higher wages, with the process continuing indefinitely on its own momentum. Such a "perpetual motion inflation machine" could not not continue on its own without continuous "refueling" in the form of an accommodative monetary policy. Yet, there is no convincing evidence that the Federal Reserve has conducted monetary policy in such an accommodative manner. Rather, the increases in the money supply have more typically acted as an underlying cause of the increases in wages and prices. More than providing the fuel to keep the engine running, an increasing money supply has apparently provided the initial spark igniting the engine.

Some might contend that at root the various theories of inflation all say much the same thing. Cost-push theorists might see income-share struggles as first affecting wages and prices, and thence forcing accommodation by monetary authorities who seek to avoid disruptions to output and employment. At the same time, monetary theorists might emphasize government efforts to achieve unattainable economic goals (or to avoid painful explicit tax increases) in order to appease impatient electorates, thereby leading to autonomous monetary expansion and thence inflation. At this level, both sides ultimately seem to blame inflation on socio-political pressures, and disagree mainly about the mechanisms which transmit these pressures.

Yet, it can be argued that the two approaches actually give rise to quite different insights and policy implications. If nothing else, the monetary approach emphasizes the importance of the money supply in continuing the inflation process, whereas this role is often left implicit in the cost-push formulation. More importantly, identifying the actual channels through which inflationary forces operate suggests different policy strategies for slowing inflation. It is true that if socio-political struggles underlie any inflation, then any effective anti-inflation policy must educate the public about the futility of attempting to resolve struggles in this way, and must devise political reforms to keep these struggles from being translated into inflation. But it is also true that if cost-push channels cannot be identified as crucial in the transmission of these struggles to inflation, as we suggest, then policy reforms should start with channels that can be identified. Thus, reform should possibly begin with the operations of monetary policy and related policy influences from the executive and legislative branches—rather than with income policies designed to control industrial sectors which have typically reacted to rather than instigated inflationary pressures. Of course alternative channels of inflationary pressures operating on the money supply (such as government spending or "finetuning" tendencies) may be just as hard to identify as cost-push pressures are.

Indeed, our study suggests that while we can easily identify money-supply expansion as a cause of inflation, we cannot easily explain why the money supply grows. Neither major set of theories—cost-push or government-spending—provides convincing evidence on this point. Fluctuations in interest rates (actually, credit market conditions) may be able to explain money-supply growth in relation to former (pre-October 1979) Federal Reserve operating procedures, but a definitive answer to this issue awaits further research.

In closing, we may note a few other implications of our results. First, the two monetary base measures exerted significant effects on many of the cost variables, and in some cases actually outperformed the broader money-stock measures. This suggests that monetary-base information can be useful in judging the inflationary impact of monetary factors when financial innovations (e.g., automatic transfers) blur the meaningfulness of the money-stock data. Thus, monetary policymaking need not be totally at a loss in times of financial innovation. Also, M-1 generally outperformed the broader M-2 measure, both in terms of the statistical reliability of its effect on various cost variables and in terms of its independence of such variables. This observation will not resolve the long-standing M-1 vs. M-2 controversy, but it should provide a useful piece of evidence on that subject.

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APPENDIX
Alternative Estimation Forms

This Appendix discusses the results of estimations of alternative equation forms for equations (1) and (2), for the variables listed in Table 2. Once again, Table 2 showed the results of estimating the equations:

$$y_t = \alpha + \sum_{1}^{8} \beta_j y_{t-j} + \sum_{1}^{8} \gamma_j x_{t-j} + \epsilon_{1t}, \qquad (1)$$

$$x_t = \delta + \sum_{1}^{8} n_j x_{t-j} + \sum_{1}^{8} \mu_j y_{t-j} + \epsilon_{2t}. \qquad (2)$$

The estimations of the equations (1) and (2), as documented so far, were done through ordinary least-squares estimation (OLS), with no constraints imposed on the structure of the lag coefficients, other than the lag-length assumption.

While this technique is common in time-series analyses and causality studies, the reader may object to the existence of multicollinearity among the regressor variables, because of the number of lagged regressors involved. A technique designed to minimize this multicollinearity and preserve degrees of freedom in estimation is that of polynomial distributed lags (PDL). This technique assumes that the coefficients of a given distributed lag are related to each other through a polynomial function. For example, in equation (1), for the lag set $\gamma_1, \ldots, \gamma_8$, a second-degree PDL specification would assert that

$$\gamma_j = aj^2 + bj + c, \qquad j = 1, \ldots, 8$$

where a, b, and c are the coefficients of the polynomial. This specification would necessitate estimation of only three parameters, a, b, and c, rather than eight, $\gamma_1, \ldots, \gamma_8$. Also, the technique for estimating this equation would use three variables, S_{1t}, S_{2t}, and S_{3t} which are linear combinations of $x_{t-1}, \ldots, x_{t-8}$, and allegedly the multicollinearity among these three variables would be less of a problem than that among the eight lagged values of X_t.

Without speculating on the validity of this technique, the equations summarized in Table 2 were re-estimated, first under a specification of second-degree PDL for all lag sets, and then under a specification of third-degree PDL for all sets. No further constraints were imposed on the lag structure. The results of these estimations are shown in Tables A-1 and A-2 respectively. Also, by comparing the results of the PDL with that of the OLS estimation of the same equation, the suitability of the PDL specification can be tested. An F-test can be derived, a significant value of which would indicate that the data are inconsistent with the PDL specification. These F-statistics are shown in Tables A.1 and A.2, along with the F-statistics for the hypothesis that the explanatory variable does not "cause" the dependent variable.

For example, consider the first set of results in Table A.1. The first F-statistic of 6.2 indicates that the effect of M-1 on the CPI is significant at the 1-percent level. The 0.8 "PDL" F-statistic (not significant) indicates that the second degree PDL assumptions for this regression are not inconsistent with the data. The 0.3 F-statistic shows that the effect of the CPI on M-1 is statistically insignificant. The 3.9 "PDL" F-statistic indicates that the PDL assumption for this regression is inconsistent with the data, i.e. that the equation regressing M-1 growth on lagged M-1 growth and CPI inflation has coefficients which do not obey a second-degree polynominal specification.

The results of Tables A.1 and A.2 are clearly similar to those of Tables 1 and 2. While the F-statistics suggest that PDL assumptions are generally inappropriate for regressions using money-supply growth—especially M-1 growth—as the dependent variable, this generally mirrors the inappropriateness of the PDL for the time-series behavior of the money supply itself. Generally, the feedback effects on inflation indicators themselves on the money supply are too weak or non-existent to be materially distorted by PDL assumptions.

Finally, Niskanen (1978) has referred to an obvious change in the conduct of monetary policy starting in the late 1960's. If policy re-

Table A.1.
Causality Tests Using an Unconstrained Second Degree Polynomial Lag Structure (Eight Quarters Long) for All Variables*

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL
All Items	6.2***	0.8	0.3	3.9***	4.2***	0.7	0.9	3.0**	3.1**	0.7	0.2	1.2	2.8**	1.1	0.3	1.6
Food	5.9***	0.7	0.4	2.9***	4.1***	0.8	0.3	2.6**	2.9**	1.3	1.2	1.0	1.3	1.0	1.4	1.2
Excluding Food	4.6***	0.7	1.0	4.2***	2.3*	0.9	1.4	2.1**	1.9	1.5	0.3	0.7	5.5***	0.8	0.6	1.2
Wholesale Prices																
All Items	5.8***	0.8	0.2	1.9*	4.5***	0.7	0.7	1.7	3.0**	0.3	0.1	0.7	1.3	1.6	0.5	1.2
Non-Farm	6.2***	1.2	0.1	2.2**	5.4***	1.2	0.7	2.2**	2.6*	1.4	0.3	0.8	2.5*	3.3***	0.5	1.1
Farm	4.1***	1.2	0.4	1.8*	3.1**	0.8	0.8	1.7*	1.7	1.1	0.5	0.7	1.4	1.5	1.1	0.9
Metals	4.7***	2.0**	0.3	2.3**	4.1***	1.4	0.9	3.0***	2.8**	2.1**	0.5	1.8*	2.8*	2.6***	0.9	1.0
Steel	3.6**	1.5	0.1	3.0***	2.3*	1.7	0.7	3.5***	2.5*	2.1**	0.2	1.2	2.7**	2.5**	1.1	0.8
Fuel	5.0***	1.4	0.2	2.1**	3.0**	1.4	0.9	1.7	2.7**	1.8*	0.2	1.0	2.9**	1.5	0.3	1.3
Petroleum	4.9***	2.7***	0.5	2.0**	1.3	3.0***	1.3	1.6	1.1	3.0***	0.2	0.8	1.5	3.2***	0.3	1.1
Wages For																
Nonagricultural Workers[3]	2.4*	2.0*	0.7	0.9	1.3	2.2**	0.1	0.8	1.9	3.2***	0.5	0.9	6.0***	1.9*	0.9	1.2
Manufacturing	3.1**	0.8	0.6	2.0*	3.7**	1.4	0.6	1.9*	4.3***	2.4**	0.4	1.2	5.7***	1.9*	0.2	1.4
Unit Labor Costs																
Private Business	6.6***	0.6	0.7	0.6	3.2**	0.7	1.1	1.4	3.5**	0.5	0.8	1.6	4.4***	0.9	0.3	0.6
Manufacturing	4.5***	1.4	0.3	0.4	3.5**	1.5	0.4	1.5	2.2*	1.7*	0.6	1.8*	2.6*	2.1**	0.3	0.9
Non-Farm	6.6***	0.7	0.5	0.4	3.3**	0.7	1.0	1.3	3.8**	0.7	0.8	1.7*	3.9**	0.8	0.3	0.6
Unemployment Rates																
All Workers[4]	6.4***	9.2***	1.2	0.3	3.7**	7.8***	1.8	1.4	2.1	8.9***	1.6	2.3**	1.5	8.1***	0.1	0.8
Males 25–44[4]	4.4***	6.0***	0.7	0.3	3.4**	4.9***	1.6	1.6	1.6	5.3***	1.0	1.6*	1.0	3.6***	0.4	1.1
Implicit Deflators																
GNP	4.5***	1.3	1.6	0.6	2.7*	1.1	1.7	1.4	4.7***	0.9	0.8	1.8*	2.9**	0.5	0.8	1.9*
Personal Consumption Expenditures	5.6***	0.6	0.5	0.8	4.3***	1.2	1.1	1.7*	3.8**	0.7	0.2	1.8*	3.9**	1.0	1.1	0.9
Government Deficit[5]	1.2	2.9***	3.5**	1.3	0.9	1.9*	3.1**	1.8*	1.6	1.8*	1.6	1.4	4.0**	2.0**	2.1*	1.8*
Deficit/GNP Ratio[4]	1.4	1.8*	0.9	1.3	0.1	2.6**	0.5	1.4	0.9	1.8*	0.5	0.8	1.3	2.1**	0.3	1.5*
Government Spending	1.0	2.6***	0.1	2.2**	0.4	2.5**	0.3	3.2***	0.7	2.9***	0.1	1.0	1.2	2.8***	0.7	1.3

*The first column in each set shows the F-statistic for the effect of the respective monetary aggregate on the "cost" variable; second column shows the F-statistic for the hypothesis that a second degree PDL fits this relation; third column shows the F-statistic for the effect of the "cost" variable on the monetary aggregate; fourth column shows the F-statistic for the PDL for this relation.

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

[1]F-statistic tests the hypothesis that the explanatory variable has no effect on the dependent variables. [2]F-statistic tests the hypothesis that the PDL constraint is consistent with the data. [3]Sample period: 1966.2–1979.2. [4]"Cost" variables are in level form. [5]This result is between the deficit and first difference in the respective monetary aggregate.

action did indeed shift starting in the late 1960's, one might expect the causality results between the money supply and various cost indicators to be different in the last ten years than in the previous ten. As a first attempt to allow for such changes, some of the results in Table 2 were re-run with a sample period consisting of 1969.2-1979.2, and a third degree PDL specification imposed to preserve degrees of freedom. Also, some of the results were re-run over the 1959.2-1979.2 period in OLS form with a dummy variable for the last ten years, in an attempt to pick up obvious shifts in the money-supply accommodation equations. These estimations did not show any substantive changes in the causality results, nor were any signs of a shift in policy behavior apparent.

Table A.2
Causality Tests Using an Unconstrained Third Degree Polynomial Lag Structure (Eight Quarters Long) for all Variables*

	M-1				M-2				St. Louis Base				Source Base			
	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL
Consumer Prices																
All Items	5.0***	0.8	0.2	4.5***	3.3**	0.8	0.7	3.7***	2.6**	0.8	0.4	1.2	2.2*	1.4	0.7	1.3
Food	4.9***	0.6	1.1	2.8**	3.8***	0.6	0.3	3.1***	3.1**	0.7	1.2	0.9	0.9	1.3	1.1	1.1
Excluding Food	3.3**	0.8	2.0*	4.1***	1.8	1.0	2.8**	1.7	1.6	1.6	0.3	0.7	4.0***	0.9	1.1	0.8
Wholesale Prices																
All Items	5.0***	0.7	0.2	2.1*	3.8***	0.7	1.3	1.7	2.1*	0.3	0.2	0.7	1.6	1.6	0.5	1.0
Non-Farm	3.8***	1.0	0.4	2.3**	3.3**	1.0	1.8	2.1*	2.2*	0.8	0.2	0.8	4.1***	1.9*	0.6	0.9
Farm	3.9***	1.0	0.3	2.0*	2.6**	0.8	0.2	2.1*	1.6	1.1	0.6	0.5	1.1	1.7	1.0	0.7
Metals	3.8***	1.6	0.5	2.3**	2.5**	1.2	2.2*	2.8**	3.1**	1.4	0.5	2.1**	4.0***	1.5	0.9	0.8
Steel	3.0**	0.6	0.5	3.1***	1.7	1.0	1.2	3.8***	2.8**	0.9	0.7	1.3	3.9***	0.9	0.8	0.7
Fuel	3.8***	1.1	0.2	2.3**	2.0	1.2	1.0	1.9*	2.0	1.6	0.7	0.8	3.0**	0.9	0.3	1.3
Petroleum	4.0***	2.8**	1.7	1.5	1.0	3.3***	1.9	1.5	1.4	3.0***	0.2	0.8	1.1	3.6***	0.4	0.9
Wages For																
Nonagricultural Workers[3]	1.8	2.3**	0.5	1.0	1.1	2.7**	0.2	0.8	1.9	3.6***	1.0	0.9	5.0***	2.1*	1.0	0.9
Manufacturing	2.2*	1.0	0.7	2.0*	2.6**	1.8	0.5	2.3**	3.5**	2.8***	0.3	1.3	4.1***	2.4**	0.8	1.1
Unit Labor Costs																
Private Business	5.6***	0.2	0.6	0.6	3.3**	0.3	1.1	1.0	2.7**	0.3	0.6	1.8	3.4**	0.8	0.2	0.5
Manufacturing	3.5**	1.6	0.4	0.3	2.8**	1.7	0.5	1.1	2.0	1.9	0.4	2.1**	2.0	2.5**	0.9	0.6
Non-farm	5.3***	0.4	0.5	0.2	3.2**	0.4	1.0	0.7	3.5**	0.4	0.7	1.6	3.5**	0.5	0.2	0.5
Unemployment Rates																
All Workers[4]	4.9***	3.6***	1.1	0.2	2.2*	3.1***	1.7	0.9	1.4	3.7***	1.3	2.7**	0.2	3.6***	0.3	0.7
Males 25–44[4]	3.7***	3.1***	0.7	0.1	2.4*	2.4**	1.6	1.1	1.8	2.3**	0.9	1.8	0.5	1.2	0.4	1.0
Implicit Deflators																
GNP	3.8***	1.4	1.3	0.5	2.5**	1.1	1.5	1.0	3.6***	1.0	0.5	2.2**	2.7*	0.5	0.5	2.2**
Personal Consumption Expenditures	4.2***	0.6	0.4	0.9	3.0**	1.4	0.8	1.4	2.8**	0.7	0.3	2.1**	3.4**	0.9	0.7	1.0
Government Deficit[5]	0.7	2.6**	2.7**	1.5	0.7	1.4	2.4*	2.0*	1.4	1.2	1.8	1.4	2.8**	1.6	2.9**	1.2
Deficit/GNP Ratio[4]	0.9	2.3**	0.7	1.3	0.1	3.2***	0.8	1.5	0.7	2.2**	0.9	0.6	1.3	2.4**	1.5	0.9
Government Spending	0.8	2.1**	0.3	2.3**	0.3	2.1**	1.2	3.3***	0.6	2.4**	0.7	0.8	1.0	2.3**	0.4	1.2

*First column in each set shows the F-statistic for the effect of the respective monetary aggregate on the "cost" variable; second column shows the F-statistic for the hypothesis that a third degree PDL fits this relation; third column shows the F-statistic for the effect of the "cost" variable on the monetary aggregate; fourth column shows the F-statistic for the PDL for this relation.
*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.
[1]F-statistic tests the hypothesis that the explanatory variable has no effect on the dependent variables.
[2]F-statistic tests the hypothesis that the PDL constraint is consistent with the data.
[3]Sample period: 1966.2–1979.2.
[4]"Cost" variables are in level form.
[5]This result is between the deficit and first difference in the respective monetary aggregate.

FOOTNOTES

1. Johnson's (1971) is the best known use of this phrase. Earlier users are cited by him as well.

2. This is obviously a very capsule treatment of the neutrality-of-money hypothesis. Among other things, it implicitly assumes 1) that economic actors do not have "money illusion," and so will not feel better (worse) off if nominal wealth and all money prices increase (decrease) by an equal proportion; 2) that government bonds do not represent net wealth to the private sector (that is, the interest payments forthcoming from them are offset by future tax revenues needed to service the debt—see Barro (1974) for a discussion of this, and Metzler (1951) for a model where the net wealth status of bonds prevents neutrality); and 3) that the distribution of wealth in an economy is not irretrievably altered by the process of convergence to equilibrium following an increase in the money supply. See Patinkin (1963), Friedman (1956), or Barro and Grossman (1976) for extended treatments of these issues.

The neutrality hypothesis does not rule out growth in output or employment over time, but only specifies that these will eventually be unaffected by the level of the money supply. Nor does neutrality imply that real variables are independent of the **rate of change** of the money supply, this latter concept being commonly known as "super neutrality."

The reader should note that these neutrality concepts, while convenient for showing the effects of money on prices, are not necessary conditions for the inflationary effects of an increase in the money supply.

3. This point is discussed in Jacobs et al. (1978).

4. Monetary discussions of inflation state that sustained changes in the rate of money-supply growth, relative to previous trends, will lead to changes in the trend rates of change in prices and wages. This description allows for the possibility that a positive rate of money-supply growth (usually estimated at about 1% per year for M-1 in the U.S.) will allow a zero inflation rate. Even in this case, it is still true that sustained changes in money growth above this rate will lead to sustained inflation.

5. Because lagged dependent variables are included in equations (1) and (2), the eight-quarter lag structure does not constrain the total lag from the explanatory to independent variables to be eight quarters or less. That is, in (1), y_t depends on $y_{t-1}, \ldots, y_{t-8}$, but since y_{t-8} depends on x_{t-16}, y_t will then indirectly depend on x_{t-16}, and a very long lag can be estimated by the equation form described in the text.

6. Deterministic seasonality refers to the perfectly predictable seasonal variation in a variable, while stochastic seasonality refers to seasonal fluctuation that varies randomly, perhaps in correlation with other seasonal variables. For example, suppose M-1's growth rate was on average 6 percentage points higher in the fourth quarter, due to Christmas financing needs, than in the first quarter. Then M-1 would have a deterministic seasonal component of 6 percent in the fourth quarter relative to the first. However, fluctuations in this seasonal difference would still exist due to random seasonal factors, and these would represent stochastic seasonality.

Deterministic seasonality can be handled by extracting seasonal means from the data, which is what seasonal dummies do in the regressions done here. Stochastic seasonality must be handled in other ways, such as through the fourth- and eighth-order autoregressive coefficients in the equations in the text.

Plosser (1975) provides a more complete discussion of these issues. Also, Sargent (1976) discusses how the use of seasonal filters to "pre-whiten" data can distort the results in Granger causality tests.

7. Also, the quarterly level observations used are **end-of-period** observations for the quarter rather than **quarterly averages.** Computing rates of change for averaged data can be shown to introduce spurious effects, and so this practice was avoided.

8. That is, the levels of the variables used here generally have increasing time trends, and so are very likely nonstationary. Therefore, percent changes were computed to attempt to induce stationarity. While inflation **rates** would also seem to have shown some trend over the last twenty years, these are, in any case, clearly more stationary than price **levels.** For the equations summarized in Table 1, the sum of the coefficients for the lagged dependent variable, while large, were uniformly below 1, in the .5–.7 range, suggesting that the implicit stationarity assumptions behind these equations hold at least approximately.

9. The St. Louis base is adjusted for shifts in deposits between large (high reserve requirement) banks and small (low reserve requirement) banks, as well as for shifts in general reserve requirements, in order to capture the "deposit-creating" power of a given stock of currency and reserves. For a detailed explanation of this series, see Anderson and Jordan (1968).

10. Using the variables in equation (1), if x were held at a stationary value x, y would approach the stationary value y, where

$$y = \alpha + \Sigma\beta_j y + \Sigma\gamma_j x, \text{ so that}$$

$$y = \alpha/(1 - \Sigma\beta_j) + [\Sigma\gamma_j/(1 - \Sigma\beta_j)]x.$$

Therefore, in the long-run, y responds to sustained changes in x by a factor of $\Sigma\gamma_j/(1 - \Sigma\beta_j)$, which is how the long-run effects in Table 1 are computed.

It is important to keep in mind that the significance of the F-statistic does not necessarily say anything about the significance of the long-run effects also shown in Table 1 (and in Table 2 below). This is because the F-statistic is for the hypothesis that the whole vector $(\gamma_1, \ldots, \gamma_8)$ in (1) (or $(\mu_1, \ldots, \mu_8)$ in (2)) is equal to a zero vector, while a test of the long-run effect would concern whether $\Sigma\gamma j$ in (1) (or $\Sigma \mu_j$ in (2) was equal to zero. Thus it could well be that the γ-vector differs significantly from zero, but that the individual coefficients vary in sign so that their sum is negligibly different from zero. Indeed, this is the case for the regressions of M-1- and M-2-growth rates on CPI inflation, as discussed in the text.

On the other hand, it should be clear that if the γ-vector (μ-vector) is not significantly different from zero, the sum of its coefficients cannot be significantly different from zero. Therefore, significance of the F-statistic is a necessary but not a sufficient condition for the significance of the long-run effect.

Tests of the significance of the long-run effect could be conducted by running another regression in which the long-run effect was constrained to zero, for (1) by imposing the linear constraint $\Sigma\gamma_j = 0$ on the data—just as the significance of the γ-vector was tested by running another regression with the 8 linear constraints $\gamma_j = 0$, $j = 1, \ldots, 8$ imposed on the equation, i.e. by dropping the x_{t-j} regressions from (1). These tests of the long-run effects were not conducted in order to economize on computer time, especially in view of the general lack of significant F-statistics for the accommodation equations initially.

11. This argument was attributed to Haberler by Milton Friedman.

12. Since the deficit and first difference in the money-supply series already have a decided trend, the seasonal means of these variables also have a trend over time, so that seasonal dummies would be expected to do a poor job of removing even deterministic seasonality from the data. Therefore, seasonally adjusted data were used for this test, further clouding the meaningfulness of its results.

13. The long-run effects can be easily computed from the estimated equations. However, computing the significance of differences in these long-run coefficients from zero or unity, involves estimating another equation (one in which the long-run effect is constrained to zero or one) and then comparing the two equations. Since a substantial number of equations had already been run in compiling Table 1, tests of the significance of the long-run effects were not generally conducted.

14. Gordon (1977) presents an interesting discussion of these and other effects, and the various theories citing them.

15. In considering these issues, Bazdarich (1978) found that money-supply growth was actually significantly lower in a number of Pacific Basin countries (including the U.S.) than would be expected given inflation and previous money growth. This also suggests a lack of accommodation in this period.

16. A similar calculation was performed by Friedman in an exchange between him and Modigliani (see Friedman and Modigliani (1977)), with much the same results.

In a subsequent part of that discussion, Modigliani claims that the Nixon Administration price controls "had no effect whatever on wages . . . (and) a small effect on prices, and that it washed out fairly quickly." Yet the simulations discussed in the text showed a run of positive simulation errors (over forecasts of inflation) during the controls period, and a run of negative errors immediately following the controls period. For example, the "bracketed sample" M-1 - CPI simulation from 1971.3–1972.4 showed six straight positive simulation errors generally larger than 2 percentage points on an annualized basis, and summing to 4 percent over "forecast" of the price level over the controls period. In 1973, when the controls were being phased out, two small overforecasts were followed by one small underforecast. Then, through 1974.4, five straight sizable under-forecasts were found, with a cumulative underforecast inflation in the post-controls period of 3.3%. This provides at least impressionistic evidence that the controls transferred price increases across periods.

Finally, even without any allowance for the possible delaying effect of controls on inflation, this simulation predicted a 9.2% CPI inflation rate in 1974—somewhat below the actual recorded rate of 12.2%, but nevertheless suggestive of a very inflationary monetary climate.

17. That is, inflation was forecasted for 1971.3 using previous money-supply growth, and this forecast amount was then used as the lagged dependent-variable value for 1971.3 in subsequent quarters, and so on. Thus, no actual 1971.3–1975.4 inflation information was used in generating these simulations, although actual money-supply growth was used.

18. Also, allowance was made for the effects of automatic transfers (ATS) on M-1. Due to the emergence of ATS, it's clear that M-1 demand would grow at a slower rate than previously, and therefore that a given rate of M-1 growth would be more inflationary immediately after the inception of ATS than before its inception. The Federal Reserve Board of Governors Staff estimates that ATS had about a 1.5% effect on M-1 growth in late 1978 and early 1979, by which time the effect was largely completed. Therefore, in these simulations, the actual levels of M-1 were increased by 0.75% in 1978.4, and by 1.5% in 1979.1 and 1979.2, so that M-1 growth rates in 1978.4 and 1979 were both increased by 0.75 percentage points. Other aggregates were not altered.

In order to continue the simulations through 1981.4, growth rates for the aggregates in the 1980.1–1981.4 period were assumed to be 5% for M-1, based on the current midpoint of the Federal Reserve's long-run target ranges.

19. That is, these simulations use actual money-supply growth through 1979.4. Since they are therefore conditioned on this information, they are not true forecasts.

20. The simulations or "conditional forecasts" shown in Table 4 represent the compounded sum of quarterly inflation forecasts for the year in question. Thus, they represent December/December or fourth-quarter/fourth-quarter measures of inflation. For this reason, lists of forecasts appearing in **Euromoney** (1978, 1979) and **Business Week** (1977, 1978) are not included in Table 4, since those forecasts were apparently on a year/year basis (using yearly average price levels). Still, this exclusion weakens the present paper's results, if anything, since the excluded forecasts are all much lower than the Table 4 results.

The forecasts shown in Table 4 were all computed on a fourth-quarter/fourth-quarter basis from published forecasts. In passing, it can be shown that year/year inflation figures inevitably involve heavy use of previously available figures, so that the ability to forecast December/December inflation rates is a better gauge of the predictive power of a given forecasting technique.

21. Actually, in view of the eight-to-ten quarter lag that occurs before money-supply expansion has had its full effect on inflation—implied by the equations estimated here and found in many other studies—the use of actual money-supply growth has little effect on predicted inflation rates in the first year of each simulation. The effect is probably less than half a percentage point, compared to simulations using, say, the midpoints of Federal Reserve target ranges or other forecasts of money-supply growth. Thus, the simulation predictions are in fact probably close to money-supply-based forecasts that might have been made at the dates shown.