The Stability of Money Demand, Its Interest Sensitivity, and Some Implications for Money as a Policy Guide

by John B. Carlson

John B. Carlson is an economist at the Federal Reserve Bank of Cleveland. The author acknowledges helpful discussions and comments from Charles Carlstrom, William Gavin, and George Tavlas. Thanks also to Christine Dingledine for meticulous research assistance.

Introduction

The money demand function is one of the most closely studied relationships in economics. One reason is that the question of the stability of money demand has long been central to issues of monetary theory. This largely reflects the influential restatement of the quantity theory of money by Milton Friedman (1956): "The quantity theory is in the first instance a theory of money demand." Further, he argued, "The quantity theorist accepts the empirical hypothesis that the demand for money is highly stable—more stable than functions such as the consumption function that are offered as alternative key relations."

Friedman did not specify precisely the meaning of "highly stable" or "more stable." Presumably, highly stable implies that the parameters of the money demand function do not change over time. Thus, one would expect that any reasonable specification of money demand might satisfy some sort of in-sample stability test (for example, Chow test) at a minimum. The notion that money demand is more stable than other "key" relationships has been interpreted in the context of a simple IS-LM framework by Poole (1970). In essence, "more stable" implied that the variance of the money demand function was *relatively* smaller than the variance of the IS curve.

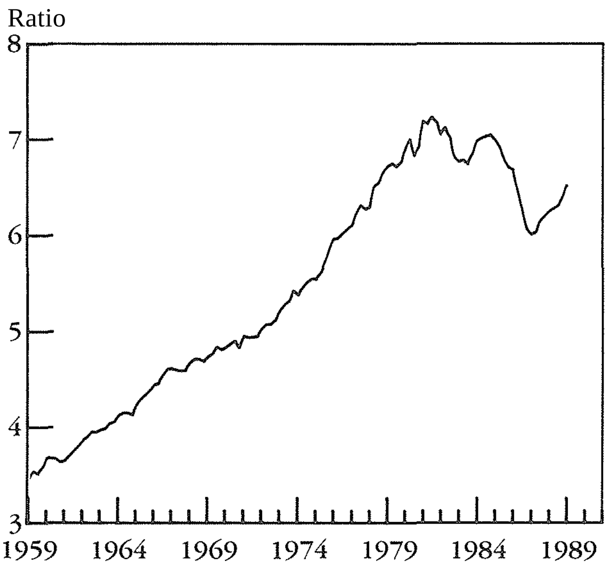
For years, the question of stability was simply examined by estimating various specifications of money demand, including both long-run and short-run models. It was commonly affirmed that money demand was a function of relatively few variables, including income and interest rates. By the mid-1970s, a consensus seemed to emerge that money demand was indeed one of the more stable relationships in economics, reliable enough to serve as a basis for formulating monetary policy.

Unfortunately, just as a consensus seemed to develop, many of the estimated relationships broke down, first around 1974, and again around 1982. By the mid-1980s, it appeared as though many economists had given up on finding a specification of money demand that might be stable, in either the short or the long run.

Recently, however, several researchers have found evidence that some specifications of money demand have remained stable through events of the 1970s and 1980s. One common conclusion of these studies is that money demand is highly interest sensitive—more so than many economists previously thought, particularly in

FIGURE 1

M1 Velocity



SOURCE Board of Governors of the Federal Reserve System

the long run. The magnitude of the interest elasticity of money demand has important implications for the role of money in the economy and hence for the conduct of monetary policy.

Much of the early debate about the role of money centered on how interest rates affected the velocity of money. Some analysts argued that interest-rate changes had little effect on velocity in the short or long run. Moreover, some presumed that M1 velocity had an inherent trend growth rate of about 3 percent. These assumptions now appear to be clearly refuted by the experience of the 1980s.

This paper reviews some recent findings of the research on money demand and considers the implications of these findings for monetary policy and rules. Section I reviews briefly a common specification of M1 demand that misled many economists about the importance of interest rates. Section II examines recent evidence that long-run equilibrium demand for the narrow money measure continues to be a stable function of relatively few variables.

The implications of these findings for the apparent shift in M1 velocity are discussed in section III. Section IV reviews the evidence that M2 demand is stable in the short run. In section V, the findings on M2 demand are reconciled with evidence that M2 velocity is trend stationary. The policy implications of the common finding that money demand is substantially interest sensitive are analyzed in sections VI and VII. Section VIII offers some concluding thoughts.

I. The Demand for M1 Before 1980

Until the 1980s, most attention in the money demand literature was given to M1—the money measure that then included currency and non-interest-bearing demand deposits. Focus on this measure reflected both theoretical and pragmatic considerations. First, M1 was the closest measure of pure transactions balances and hence conformed well to the concepts embodied in the inventory-theoretic model of Baumol (1952) and the portfolio-choice theory of Tobin (1958). These approaches essentially explained why individuals would hold the non-interest-bearing components of M1 instead of interest-bearing alternatives.

Perhaps more important, the focus on M1 seemed justified on empirical grounds. Of the various money measures, M1 appeared to be most closely related to economic activity, particularly in the short run. Movements in M1 served as a relatively useful indicator of current and future changes in economic activity. Moreover, the velocity of M1 exhibited a high degree of stability. From 1959 to 1980, M1 velocity increased at a trend rate of around 3 percent, deviating only a few tenths of a percent from year to year (see figure 1).

By the 1970s, a conventional empirical model for M1 demand had evolved.[1] Desired real M1 balances, m^*, were a function of some scale variable, y, either real income or wealth; and a measure of the opportunity cost of holding money, r, the level of interest rates:

$$(1) \quad m^* = \alpha_0 + \alpha_1 y - \alpha_2 r$$

Earlier studies used annual data (see Meltzer [1963], Laidler [1966], and Chow [1966]). In these studies, the scale variable was typically some measure of wealth, and the opportunity cost was most often a measure of the long-term interest rate. The interest elasticities for M1 ranged between –0.7 and –0.9.[2]

1 See, for example, Goldfeld (1973)

2 For a more complete discussion of earlier studies, see Havrilesky and Boorman (1978), chaplers 7 and 8.

Later studies in money demand used quarterly data, perhaps motivated by the increasing availability of such data and the development of quarterly econometric models (see Goldfeld [19731). It became more common to use real income as the scale variable and to use a measure of the short-term interest rate as the measure of opportunity cost. It was often assumed that in any given quarter, money balances adjusted only partially to their desired (equilibrium) level. The adjustment process was specified as

$$(2) \qquad m_t - m_{t-1} = \lambda(m^* - m_{t-1}),$$

where A is the speed of adjustment to equilibrium. Substituting equation (1) into (2) yields

$$(3) \qquad m_t = \lambda\alpha_0 + \lambda\alpha_1 y_t - \lambda\alpha_2 r_t + (1-\lambda)m_{t-1}.$$

Equation (3) was sometimes estimated in first-difference form.[3]

The speed of adjustment of M1 balances to equilibrium levels was typically estimated to be between 0.25 and 0.5 per quarter. The estimates of income elasticities of this specification were typically around 0.2 in the short run and less than unity in the long run. Estimates for interest-rate elasticities were around –0.02 in the short run and ranged between –0.05 and –0.15 in the long run.[4]

The estimates of long-run interest elasticities seemed lower than the theories predicted and were substantially lower than earlier estimates. Given the absence of any evident interest-rate effects on M1 velocity and the apparent stability of the short-run specifications through the early 1970s, the smaller estimates of interest elasticity appeared to have gained greater acceptance.

By the 1980s, however, the quarterly specifications for M1 demand failed miserably. This was evident in the sharp change in the behavior of M1 velocity, which has varied substantially since 1980 and exhibits no clear trend. The breakdown in the conventional relationship is believed to be largely a consequence of disinflation and financial deregulation.[5]

Disinflation and financial deregulation greatly affected the opportunity cost of M1. Disinflation resulted in sharply falling interest rates, reversing the secular trend that dated back to the 1950s. Deregulation allowed banks to compete more effectively for funds by offering interest-bearing checking accounts and market rates of interest on savings and time deposits. The opportunity cost of most bank deposits fell markedly after 1982 when market rates fell and when banks priced deposits more competitively.

II. M1 Demand Revisited

While attempts have been made to rectify M1 demand in the short run, no consensus appears to be forming on any particular specification (see Moore, Porter, and Small [1988]). Many analysts now question whether a short-run demand function can ever be identified for M1.[6] On the other hand, recent studies by Poole (1988) and by Hoffman and Rasche (1989) suggest that the long-run (equilibrium) relationship may have endured through the past decade. Their specifications find that the long-run equilibrium interest elasticity of M1 demand is substantial.

Poole offers an explanation for why some economists may have been misled from models estimated in first-difference form. Such models often included a constant term, which made it equivalent to a linear-time-trend specification in a regression using the levels of the data. Me concludes that in the postwar period, the constant term incorrectly picked up the trend in velocity, which should have been attributed to the postwar trend in interest rates.

This argument fails to explain, however, why the regressions for M1 in levels form (without time-trend variables) also underestimated interest elasticities. Closer inspection of the conventional relationships reveals that part of the trend effect of interest rates on M1 may have mistakenly been attributed to the trend in income. As noted above, the long-run income elasticity was typically estimated to be less than one—often around one-half. This, in turn, implied that over long periods, velocity would increase at approximately half the rate of increase in income, other things being equal. Since the conventional estimate of income elasticity concurred with the .

8 The inclusion of lagged money was also rationalized on an expectational basis (see Havrilesky and Boorman).

4 Some specifications included interest paid on passbook savings deposits as an additional measure of opportunity cost.

5 Some economists believe that the breakdown in the conventional relationship was also a consequence of the change in the Federal Reserve's operational procedure in October 1979 and the implications of that regime change on structural coefficients.

6 Poole (1988) discusses the difficulties of identification from a buffer-stock perspective of money demand and concludes that the econometric problems may well be insurmountable. For a review of the buffer-stock approach to money demand, see Laidler (1984).

inventory-theoretic models of transactions balances, many analysts accepted the low estimate as a confirmation of the theory?

To estimate long-run money demand, Poole advocates a simple regression of the level of velocity on the level of a long-term interest rate using annual data. By excluding income as an explanatory variable, Poole implicitly constrains the income elasticity to be unitary; hence, any potential trend in velocity must be independent of any trend in income.

Poole's case for using a long-term interest rate is predicated on the assumption that equilibrium money demand would not likely be affected by *temporay* changes in interest rates in the long run. Investment in cash management techniques is costly and hence only profitable when interest-rate increases are sustained. Since long-term rates are believed to embody expectations about future short-term rates, a rise in long-term rates is likely to indicate a more permanent rise in the general level of interest rates. Thus, Poole concludes, long-term rates better measure the opportunity cost of cash.

Finally, Poole argues that adequate estimates of a money-demand function cannot be obtained by using postwar data alone. During this period, both short- and long-term rates rose secularly. Thus, he uses an extensive sample period, 1915-1986, and three different subsamples. He estimates that the interest elasticity is around –0.6 for the whole period and for various subsamples, which is substantially larger than conventional estimates.

Hoffman and Rasche obtain estimates of a similar order of magnitude using a different estimation and testing method. Unlike Poole, they do not constrain the income elasticity to be unitary. Their approach — based on the notion of cointegration — addresses a potential problem related to the statistical properties of the variables included in money demand.

As with most economic variables, M1, interest rates, and income are nonstationary in levels. In such variables, there is no tendency to systematically return to a unique level or trend over time. It is now well known that standard regression analysis can yield spurious relationships between variables when the variables drift over time.

Methods initially developed by Engle and Granger (1987) allow one to examine whether equilibrium relationships exist between nonstationary variables. Such variables are said to be cointegrated, if some linear combination of them is stationary. Thus, cointegration implies a long-run equilibrium relationship between variables, and one can obtain long-run elasticities from the cointegrating vector.[8]

Hoffman and Rasche test for cointegration and find that 1) real M1 balances and real income are not cointegrated by themselves; 2) real M1, real income, and the interest rate are cointegrated with one cointegrating vector; and 3) one cannot reject the hypothesis that the coefficients of real money and real income in the cointegrating vector are equal in value but opposite in sign?

The first result is consistent with the common finding that M1 velocity is nonstationary. Since both income and money are nonstationary, but not cointegrated, their difference will be nonstationary. The second result, however, implies a stable long-run relationship between money, income, and interest rates. The third result implies that it is appropriate to interpret the cointegrating vector as a linear combination of M1 velocity and interest rates or, equivalently, that the equilibrium real income elasticity of demand for real balances is unity.

To estimate the equilibrium interest-rate elasticity, Hoffman and Rasche consider both a short-term rate (three-month Treasury bill) and a long-term rate (10-year Treasury bond). Like Poole, they find that the interest elasticity on the long-term rate is about –0.6, while somewhat less, –0.4, for the short-term rate. Moreover, they find that cointegration holds for either of the long- or short-term measures. These results are robust across subsample periods investigated.

III. M1 Velocity in the 1980s

The Hoffman and Rasche findings imply that any observed drift in the velocity of M1 should be proportional to any drift in nominal interest rates. Thus, any shift in the drift of velocity should be the mirror image of any shift in the drift of nominal interest rates. Rasche (1989) investigates this last property by examining regressions of the changes in the log of M1 velocity and changes in the nominal interest rate, each against a constant and a dummy variable, which is zero through December 1981 and 1.0 thereafter.

7 Other economic explanations for why an income elasticity might be less than one include improvements in cash management technology.

8 For a more precise description of the concepts of cointegration, see Engle and Granger (1987).

9 All variables are in log form.

The results indicate significant shifts in the interest-rate equation and in the velocity equation, both in the same direction. Again, the results hold for both long- and short-term rates; but, because of the high variance in the short-term rates, the shift is not measured with any precision. Rasche concludes that the abrupt change in the pattern of M1 velocity in the early 1980s was incleed asscxriated with a coincidental change in the drift in interest rates.

Rasche further investigates the hypothesis that the observed change in velocity behavior is a result of a break in inflationary expectations. He argues that if the postwar period through 1980 is characterized by a steady upward drift in inflation, then it is reasonable to conjecture that it has been asscxriated with the observed positive drift in nominal interest rates. Moreover, he argues that if inflation expectations stabilized at a lower rate in the early 1980s, it is reasonable to conclude that there has been no drift in interest rates over this period.

As evidence for a break in the drift of inflationary expectations, Rasche notes the general consistency of the Livingston Survey data. These data, which begin in the late 1940s, provide annual inflation forecasts formed at the end of the previous year. The survey reveals a general upward trend through 1980 and then a break sharply downward. Rasche notes that since 1982, the Livingston series has fluctuated without a trend in the 3 percent to 5 percent range.

To summarize, the recent evidence of large long-run interest elasticities of M1 demand provides a basis for understanding the recent shift in the trend in velocity. While the evidence points to a reasonably stable long-run M1 demand function, no one yet seems to have identified a satisfactory short-run model. Without a reliable short-run model of M1, little can be said about M1 velocity in the short run.

IV. The Demand for 1 2

Recent research on M2 demand provides evidence of stable specifications for M2 in the short run, at least in the postwar period. Moore, Porter, and Small (1988) estimate a short-run M2 demand function over the period 1964:IQ to 1986:IIQ.[10] The model is specified in two parts. One is an equilibrium money demand function, similar to equation (1):

$$(4) \quad m_t = \alpha + y_t + \beta s_t + e_t,$$

where m_t = log (M2), y, = log (nominal GNP), and s = log (opportunity cost). Note that the unitary coefficient on nominal GNP assures that this also specifies a velocity relationship.[11] The second component is a dynamic specification based on an error-correction adjustment:

$$(5) \quad \Delta m_t = a + be_{t-1} + \sum_{i=1}^{u} c_i \Delta m_{t-i} + \sum_{i=0}^{v} d_i \Delta s_{t-i} + \sum_{i=0}^{w} f_i \Delta y_{t-i} + \epsilon_t,$$

where e_{t-1} is the deviation of money from its long-run equilibrium value (derived from [4]) and ϵ_t is white noise.

Equation (5) essentially specifies the short-run convergence process of M2 to its equilibrium value. When the coefficient b is negative, convergence is assured. Substituting equation (4) into (5) yields

$$(6) \quad \Delta m_t = a - b\alpha - b\beta s_{t-1} + b(m_{t-1} - y_{t-1}) + \sum_{i=1}^{u} c_i \Delta m_{t-i} + \sum_{i=0}^{v} d_i \Delta s_{t-i} + \sum_{i=0}^{w} f_i \Delta y_{t-i} + \epsilon_t.$$

Moore et al. estimate a version of equation (6). Simulations, both in-sample and out-of-sample, support the hypothesis that M2 demand has been and continues to be reasonably stable over the whole sample period.

One key feature of Moore et al. is the way opportunity cost is measured. By definition, the opportunity cost of money is the forgone interest income of holding a monetary asset. Over the years, it has been common to use a market yield on a relatively risk-free asset, such as a Treasury bill, to measure opportunity cost. For much of the postwar period, this seemed appropriate for the narrow money measures, since holders of currency and demand deposits did not receive explicit interest payments on these instruments.

Many instruments in the broader monetary aggregates like M2, however, have yielded explicit interest. Their yields, when not exceeding interest-rate ceilings, responded at least partially to market conditions. Moore et al. measure the opportunity cost of these instruments as the

10 For further evidence concerning the stability of M2, see Hetzel and Mehra (1987).

11 Moore et al. include a time index as a regressor to directly estimate any drift in M2 velocity. While they find the coefficient to be significant, the drift is negligible at around .003 percent per year.

difference between their yield and the yield of a Treasury bill. The opportunity cost of M2 then is the weighted average of the opportunity costs of each M2 component, where the weights are equal to the component's share of M2.

The response of money demand to changes in market interest rates in this model requires a specification of the relationship of deposit sates to the market rates.[12] Thus, the interest elasticity of money demand now depends on how rapidly banks adjust their deposit rates in response to changing market rates. To illustrate, consider the extreme case where deposit rates respond instantaneously to changes in market rates so as to maintain a constant spread between them. In such a case, money demand and velocity would be unaffected by changes in market interest rates because the opportunity cost of money would not change.

If, on the other hand, deposit rates adjust instantaneously but only partially to a change in interest rates (that is, not point-for-point), then the interest elasticity would be proportional but less than the opportunity cost elasticity. Any trend in interest rates would also be associated with a trend in the opportunity cost of those deposits. Equilibrium money demand would hence be affected, and the trend in velocity would be proportional to the trend in the opportunity cost of M2.

Finally, consider a case where deposit rates respond sluggishly to changes in open market rates. A permanent increase in market interest sates would initially be associated with an increase in opportunity cost, as market rates moved above deposit rates, followed by a decrease as deposit sates caught up. If the deposit sates ultimately adjusted point-for-point, the long-run equilibrium level of opportu~iity cost would be unaffected.

Moore et al. specify deposit-rate equations to be simple linear functions of the federal funds sate. They assume that competitive forces ultimately drive the slope coefficients to equal one minus the marginal reserve ratio, and the intercept to equal some negative value to reflect transactions costs that are not recovered as fees assessed to the depositor. As with M2 demand, the short run is formulated within an error-correction framework. Changes in deposit rates are assumed to be related to deviations of the rates from their long-run equilibrium values, and to changes in the current and past values of interest sates.

Moore et al. find that for many components of M2, own rates have been relatively slow to adjust. This is particularly evident for instruments with transactions features such as NOW accounts and, to a lesser extent, money market deposit accounts. On the other hand, some deposit rates, such as those on time deposits, have adjusted relatively quickly and fully to changes in market rates.[13] However, because a significant share of M2 deposit rates adjust sluggishly, changes in market interest rates have substantial short-run effects on the opportunity cost of M2, and consequently on its demand.

Indeed, the model estimated by Moore et al. suggests that the *short-run* interest elasticity of M2 demand is substantial. What is curious is that some bank deposits appear more interest sensitive than before deregulation. One might expect just the opposite, as deregulation allows banks to compete more effectively for funds, even if they adjust only slowly.

Some analysts have speculated that the increased sensitivity of some deposits may reflect the increased sophistication of most deposit-holders and the improved communications technologies that have made funds transfers more convenient. Even if opportunity costs are less affected by changes in interest rates now than before, deposit-holders are much more aware of alternative assets and therefore are more likely to respond to changes in the opportunity cost of some deposits.[14]

V. M2 Velocity

The treatment of opportunity cost as distinct from the market interest rate helps to reconcile why M2 velocity is trendless despite the observed trends in interest rates. This is easiest to understand in the case where deposit rates ultimately adjust point-for-point with changes in market rates. In such a case, opportunity cost is by definition stationary around some trendless differential, and hence would be independent of any trend in interest rates. Thus, the velocity of these deposits would be insulated from changing inflationary expectations.

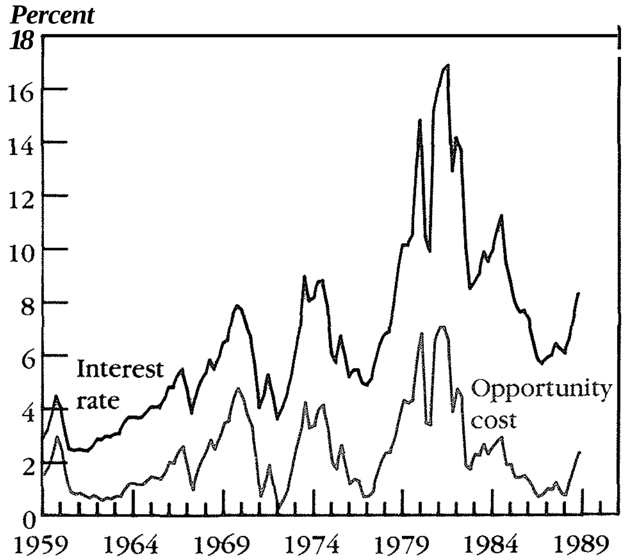
12 The advantages of measuring opporlunity cost as a differential in yields are in principle greater since deregulation than before. Currently, there are no inlerest-rate ceilings on any of M2's noncurrency and non-demand-deposit components, which are 83 percent of the total.

13 Moore et al. also conclude that deposit-rate adjustments are asymmetric, adjusting more rapidly to upward movements in market rates than to downward movements.

14 However, there appears to be no shift in the opporlunity cost elasticity of the M2 aggregate after deregulation.

FIGURE 2

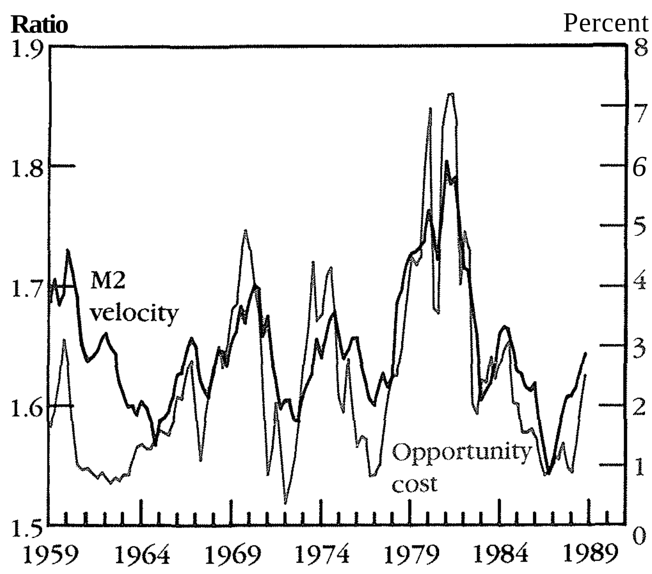
Interest Rate and Opportunity Cost of M2



SOURCE: Board of Governors of the Federal Reserve System.

FIGURE 3

M2 Velocity and Opportunity Cost



SOURCE: Board of Governors of the Federal Reserve System.

However, not all deposits in M2 adjust point-for-point to changes in interest rates. Reserve requirements assure some wedge preventing complete adjustment. Also, since currency pays no explicit yield, its opportunity cost is essentially equal to the interest rate. Thus, if the level of interest rates exhibits drift, the opportunity costs of these components of M2 will also exhibit drift in the same direction. M2 velocity would not be independent of the level of interest rates.

In practice, however, the drift in the opportunity cost of M2 has been highly muted relative to the drift in interest rates (see figure 2). The wedge created by reserve requirements is in fact small—12 percent or less. Moreover, the share of currency and reservable deposits amounts to less than 20 percent of M2; thus, the nonstationary component of the opportunity cost would be small and perhaps negligible. Interest-rate trends, then, would not affect M2 velocity substantially in the long run.

Some evidence indicates that M2 velocity is, in the long run, independent of interest rates. Engle and Granger (1987) conclude that nominal income and M2 are cointegrated, implying that M2 velocity is a stationary process and hence is unaffected by interest-rate trends. Thus, it would appear that M2 velocity is immune to changing inflationary expectations in the long run. This explains why the M2 velocity trend, unlike that of M1, was unaffected by the rise and fall of inflation in the postwar period. In the short run, however, changes in the opportunity cost of M2 are driven largely by changes in market interest rates; and, as figure 3 illustrates, M2 velocity is quite closely related to the opportunity cost of M2.

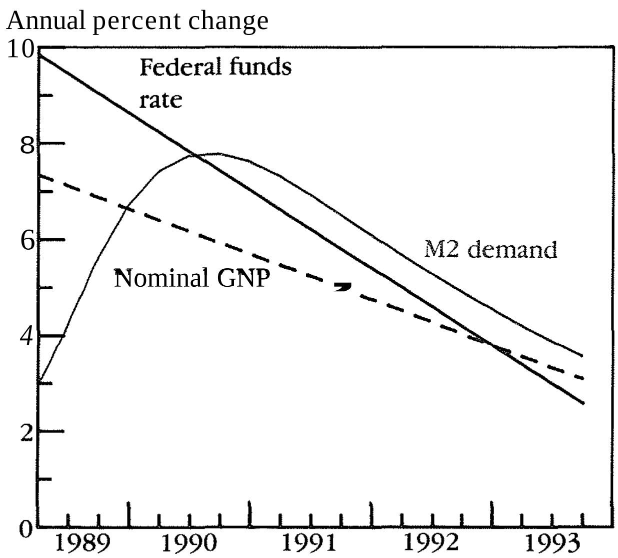
VI. Money as a Policy Guide During Disinflation

Recent evidence indicating that money demand is substantially interest sensitive has important implications for monetary policy. Interest sensitivity of money demand poses serious problems for policies that seek to achieve disinflation. Poole (1988) concludes, "There is a serious and probably insurmountable problem to designing a predetermined money growth path to reduce inflation..." (p. 97).

Poole offers a clear description of the problem: If policymakers embark on a credible policy of disinflation, they should expect that nominal interest rates will ultimately fall as inflationary expectations subside. Consequently, they should expect velocity growth to decline, and perhaps even become negative, if the policy becomes successful. Under these circumstances, inflation

FIGURE 4

Hypothetical M2 Demand: Credible Disinflation



SOURCE: Author's calculations

could be reduced without a decline in money growth, at least initially. Indeed, a decline in money growth might have a significant depressing effect on the economy. He concludes that the gradualist prescription of predetermined reductions in money growth would not be politically sustainable, as it would likely be associated with unnecessary weakness in economic activity.

Poole further argues that this situation poses a serious dilemma for policymakers. How do they convince markets of their commitment to disinflation without a reduction in money growth rates? Is it not irrational to bet on lower inflation on the basis of a central bank's promises, with no evidence that the central bank is reducing money growth? Poole concludes that a recession may be necessary to convince markets that the central bank is committed to a disinflationary policy.

The problem of targeting money is easy to appreciate in the context of M1. After all, few analysts anticipated the magnitude of the shift in the drift of M1 velocity. Another reduction in inflation would likely result in another shift in the trend in M1 velocity. Moreover, no specification for short-run M1 demand seems acceptably stable at present. On the other hand, there is no evidence that the trend of M2 velocity has been affected by the transition to lower inflation in the 1980s. The recent specification by Moore et al. suggests that the short-run demand for M2 may be reasonably stable.

A hypothetical example illustrates how the problem applies to a disinflation policy specified as a target path for M2. First, assume that on the basis of a promise alone, markets could be convinced of a central bank's commitment to gradual disinflation from current levels to zero inflation in 1993. To the extent that disinflation was perfectly anticipated, we might expect that nominal magnitudes such as interest rates, personal consumption expenditure growth, and nominal GNP growth would decline smoothly to noninflationary trend paths.[15]

If the parameters of the M2 demand function estimated by Moore et al. are approximately structural, then we would expect M2 demand to accelerate initially to growth rates above the equilibrium rate of nominal GNP growth and then begin to slow (see figure 4). The additional money growth would not be for the purpose of financing future spending, but would reflect a pure portfolio decision to hold a greater proportion of wealth as bank deposits in response to a sharply falling opportunity cost; hence, the monetary acceleration could still be associated with a slowing in nominal spending.

The pattern of M2 growth reflects two key features of the M2 demand model. First, own rates on deposits adjust slowly enough to changes in market rates that the opportunity cost in the short run is directly related to changes in the level of interest rates.[16] Second, M2 demand is substantially sensitive to changes in opportunity cost. Thus, as interest rates fall with disinflation, so does the opportunity cost of M2. It is this decline in M2's opportunity cost that induces investors to hold additional bank deposits relative to their spending needs.

This example is hypothetical, of course. If markets were to maintain an expectation of gradual disinflation, they would need to understand the consequences of a falling opportunity cost and have confidence that the estimated *short-run* M2 demand function was reliable. Only then might markets reconcile an accelerating money-growth path with a disinflation policy.

15 We assume here that in noninflationary equilibrium, growth in nominal GNP and personal consumption expenditures equals 3 percent, as does the Treasury bill rate, but that the federal funds rate equals 2½ percent.

16 This, of course, presumes that banks have a rational basis for adjusting some deposits more sluggishly than others. Thus, although market interest rates fully anticipate disinflation, bank deposits would respond with some delay.

The 22-year estimation period for M2 demand is relatively short, however, and it is not evident that deposit-rate pricing has stabilized since deregulation. It would seem doubtful that markets could be convinced of such a strategy.

Nevertheless, the evidence of substantial interest sensitivity of velocity in the short run suggests that policymakers might sometimes prefer to accommodate the effects of interest-rate changes on money demand. During periods of disinflation, one might then expect wide swings in money growth. Once a disinflation strategy becomes credible, velocity could fall substantially, if only temporarily, and it would be appropriate for policymakers to accommodate the consequent surge in money demand.

VII. Interest Sensitivity and Monetary Rules

Apart from the problems that arise during disinflation, the evidence that M2 is more interest-sate sensitive than previously thought raises some interesting issues concerning monetary rules. On the one hand, shocks to money demand would have smaller real consequences under a constant-money-growth rule than previously thought. Consider a positive shock to money demand. Given an inelastic money supply, interest rates would need to rise and output would need to fall. In conventional macroeconomic models, interest rates would respond initially. Higher interest rates would, in turn, tend to slow economic activity. When the interest elasticity of money demand is high, smaller interest-rate changes are required to offset demand shocks, implying smaller adjustments in output.

On the other hand, the consequences of non-monetary shocks under a constant-money-growth rule are less clear when the demand for money (and hence velocity) is highly interest-elastic. This longstanding issue is illustrated simply in a debate between Johnson (1965) and Friedman (1966). Johnson argued that interest-sensitive money demand militated against a constant-monetary-growth rule "...because variations in interest rates generated by the real sector would make such a rule automatically destabilizing..." (p. 397). Implicitly, Johnson assumed that variations in interest rates would be a natural by-product of stable output growth; in turn, these variations would cause procyclical variations in velocity, which, under the assumption of constant money growth, would produce fluctuations in the rate of nominal income growth.

Friedman acknowledged this potential outcome, but argued that the conditions assumed by Johnson were highly special. Essentially, Friedman contended that while velocity would tend to move with nominal output, a constant-money-growth rule would nevertheless dampen output fluctuations relative to "discretionary" policies. Thus, Friedman was not comparing his rule to an ideal rule, but to the existing practice of the central bank.

It is useful to separate this debate into two issues. The first is the general issue of rules versus discretion. The second is the question of whether monetary rules (or targets) should allow for some kind of systematic (that is, automatic) feedback to account for interest-rate changes and, hence, shifts in velocity. More specifically, should a rule or targeting procedure anticipate changes in interest rates? This first issue is only indirectly relevant to the question of interest-rate sensitivity and therefore is not dealt with here.[17] The question of feedback, on the other hand, is relevant whether a policy admits some discretion or not.

The feedback issue depends on the kinds of shocks that occur and on the poorly understood dynamics of adjustment in the economy. Specifically, it depends on where shocks arise in the economy, what their relative magnitudes are, and how they are propagated through the economy. The answers to these questions depend on the particular model one believes is appropriate for characterizing the economy. Unfortunately, no consensus exists or even seems imminent.

One large and influential class of empirical models, sharing a common propagation mechanism, casts some doubt on the efficacy of *constant* monetary-growth rules. In these models, the inflation process is characterized by an output-gap accelerationist mechanism:

$$\dot{p}_t - \dot{p}_{t-1} = \alpha_0 + \alpha_1 (q_t - q_t^*) + \alpha z_t ,$$

where $\dot{p}$ is the inflation rate, q is the level of output, q^* is full-employment output, and z represents other factors. If z is constant, a change in the inflation rate depends on the output gap. When output exceeds full-employment output (that is, when unemployment is below its natural rate), inflation accelerates. When output is below full-employment output, inflation decelerates. Anderson and Enzler (1987) explain the consequences of such a mechanism for a monetary rule:

17 For a discussion of the general issue of rules versus discretion, see Carlson (1988).

> It is easy to see why holding the money growth rate constant might not result in a stable simulation path for a macromodel containing this mechanism. The fixed money growth path predetermines both the rate of inflation and the price level consistent with the economy's steady-state path at each point of time. Consider what happens if the price level is disturbed upward from the steady-state growth path. The demand for money is increased and interest rates rise. This depresses output and increases unemployment. The increased unemployment, in turn, depresses the rate of change of prices. As long as the price *level* remains too high, a force is created that tends to keep unemployment above its natural rate and the *rate of inflation* continues to fall. The declining rate of inflation eventually returns the price level to its steady-state value, and this in turn allows the unemployment rate to return to the natural rate, but at this point *inflation* is too low to be consistent with the fixed money growth path and the price level falls through the steady-state level. This reduces the demand for money, causing interest rates to fall until unemployment is below the natural rate. Inflation then accelerates until at some point it reaches its steady-state value. But now the *level* of prices is too low. The mirror image of the previous events takes place and overshooting occurs again. (p. 297)

While the estimated parameters of these models suggest that the cycle described above eventually converges, the process is generally only slightly dampened.[18]

Because the estimated interest elasticity of output in these models is typically relatively small, it is likely that a higher interest elasticity of money demand would only attenuate the cycles of such models. To illustrate this point, consider again the propagation of the upward price disturbance. The higher the interest elasticity of money demand, the lower the rise in the level of the interest rate that would result as an effect of the price shock on money demanded, given an inelastic supply. However, because the interest-rate elasticity of output is low, the consequent effect on output would be even smaller, and would hence slow the process that dampens the shock to inflation.[19]

Evidence of a potential for long macroeconomic cycles is not a unique consequence for models with an output-gap mechanism. Indeed, some simple models linking money and prices also exhibit long cycles. One example is a recent single-equation model estimated by Hallman, Porter, and Small (1989). Theirs is a reduced-form model of the relationship between inflation and M2 that does not explicitly include either the current level of output or employment as a variable.[20] While they find rather lengthy adjustments to simulated shocks (for example, more than 100 years), the cycles of their model are more damped than those of many large macroeconomic models.

From a deterministic point of view, the Hallman et al. results suggest that there is a *nonconstant* money-growth path consistent with a relatively smooth *transition* to equilibrium. As they note, inflation, *in equilibrium*, could be controlled at any constant rate with constant growth of M2.

Notwithstanding the well-known critique of Lucas (1976), the use of deterministic simulations as evidence in the debate about an appropriate policy rule is of only limited value. A critical issue in this debate is how a rule performs in a stochastic framework, one that approximates the *distribution* of disturbances that have historically affected the various sectors of the economy. In this context, the issue is not the selection of an appropriate policy response to a particular shock, but the robustness of a contractual commitment to a policy rule in responding to a *series* of likely outcomes arising from a typical distribution.

One sense of robustness has been stressed by McCallum (1788): that a rule perform well for a variety of models, preferably ones incorporating alternative views of macroeconomic relationships. It is important to establish robustness (in this sense) because no structural model of the economy enjoys sufficiently wide acceptance; nor does any consensus seem to be evolving. Thus, to gain acceptance for a proposed rule, the rule advocate must demonstrate that the rule would lead to reasonably good outcomes for variables of interest *and* for a variety of models.[21]

18 It should be noted that these models typically do not result in a trade-off between inflation and unemployment in the long run.

19 It is perhaps ironic that these models suggest that a constant-money-growth rule would result in an interest-rate path that is too smooth to substantially dampen shocks lo inflation over reasonably short horizons. Indeed, these models suggest lhat rather large and sustained increases in interest rates would be required to substantially affect the output gap and hence the inflation rate. However, it is uncommon to find antagonists of the money-growth rule who cite this evidence and also publicly advocate the kind of interest-rate variation that large models suggest is required to stabilize the inflation rate.

20 Nevertheless, the model incorporates estimates of full employment output and equilibrium velocity as determinants of the equilibrium price level. In lhis model, inflation is a function of the gap between the cunent price level and its equilibrium level.

21 One method of simulation designed to address this issue is suggested by Tinsley and von zur Muehlen (1983). They essentially offer a technique to generate unplanned disturbances consistent with the error structure observed in historical experience. The robustness of a policy rule is tested by multiple simulations of the performance of the rule over multiyear periods, where each simulation draws a different series or "history" of unplanned disturbances. The horizons are chosen to be long enough to allow significant differences to emerge among the alternative policies and to assure that policies ultimately stabilize outcomes.

The sum of simulation results provides distributions of outcomes for each of the model's variables. For instance, one policy may be associated with a wide

Stochastic simulations, however, are costly to obtain. Moreover, a test for robustness is an open-ended search, encompassing an endless variety of both rules and models. As a consequence, evidence from this analysis is in only an embryonic state. Preliminary results by Tinsley and von zur Muehlen (1983) and Anderson and Enzler (1987) suggest, however, that monetary rules do not perform as well as alternative rules or intermediate targeting procedures. Nevertheless, the monetary rules and targeting procedures examined were based on older, less interest-sensitive estimates of money demand.

The ongoing debate over the efficacy of a constant-money-growth rule, when the interest elasticity of money demand is large, is not likely to be resolved without some convincing empirical basis. Thus, it would seem appropriate for policymakers to take account of the consequences of expected interest-rate changes on velocity when choosing target ranges for M2 over a period of a year or less. That is, it may be appropriate for M2 growth to slow substantially when interest rates are rising and expected to rise further, or to accelerate substantially when interest rates fall.

VIII. Concluding Comments

One common finding of recent empirical research in monetary economics is that the interest elasticity of money demand is estimated to be substantial, and higher than many economists previously thought. The evidence seems strongest for M1 demand in the long run. While interest rates have little long-term effect on M2, the short-run elasticity seems to be greater than previously thought.

When the interest elasticity of money demand is high, velocity can vary widely. This creates a problem for using money as a policy guide. Monetary targets should take into account the consequences of expected changes in interest rates on money demand. This problem is perhaps most difficult during periods of disinflation, when changing expectations about inflation result in large swings in interest rates and hence in velocity.

Finding that a money-demand function is stable is not a sufficient basis for adopting a constant-money-growth rule. The rule advocate has the burden of convincing others that the stabilizing effects of the monetary rule would outweigh the potentially destabilizing effects of maintaining constant money growth when velocity varies systematically with interest rates. Because no consensus exists about the best model for the economy, the rule advocate must argue his case in the context of a variety of models.

The challenge of examining rule robustness has been recognized and addressed by McCallum (1988). It is hoped that others will follow his lead. Recent developments in simulation methods offer promising approaches for examining the robustness of alternative policy rules.

range of outcomes for output and Interest rates, but with a small range for prices and money for any given simulation horizon. Another policy may be associated with small ranges for interest rates and money, but with large ranges for prices and output, or vice versa. Tinsley and von zur Muehlen note, "...the essential contribution of stochastic simulation analysis is the empirical premise that while individual unplanned disturbances cannot be predicted (by definition), their ranges of probable outcomes are unlikely to differ significantly from the dispersions observed in historical experience ..." (p.16).

References

Anderson, Robert and Enzler, Jared J., "Toward Realistic Policy Design: Policy Reaction Functions that Rely on Economic Forecasts," in Rudiger Dornbusch, Stanley Fischer, and John Bossons, eds., *Macroeconomics and Finance: Essays in Honor of Franco Modigliani*, Cambridge, Mass.: MIT Press, 1987, 291–330.

Baumol, William J., "The Transactions Demand for Cash: An Inventory Theoretic Approach," *Quarterly Journal of Economics*, November 1952, *66*, 545–56.

Carlson, John B., "Rules Versus Discretion: Making a Monetary Rule Operational," *Economic Review*, Federal Reserve Bank of Cleveland, Quarter 3, 1988, 2–13.

Chow, Gregory C., "On the Long-Run and Short-Run Demand for Money," *Journal of Political Economy*, April 1966, 74, 111–31.

Engle, Robert F. and Granger, C.W.J., "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, March 1987, 55, 251–76.

Friedman, Milton, "The Quantity Theory of Money—A Restatement," in Milton Friedman, ed., *Studies in the Quantity Theory of Money*, Chicago: University of Chicago Press, 1956, 3–21.

———, "Interest Rates and the Demand for Money," *Journal of Law and Economics*, 1966, 71–85.

Goldfeld, Steven M., "The Demand for Money Revisited," in Arthur M. Okun and George L. Perry, eds., *Brookings Papers on Economic Activity*, 1973, *3*, 577–638.

Hallman, Jeffrey J., Porter, Richard D., and Small, David H., "M2 per Unit of Potential GNP as an Anchor for the Price Level," *Staff Study No. 157*, Board of Governors of the Federal Reserve System, April 1989.

Havrilesky, Thomas and Boorman, John, *Monetary Macroeconomics*, Arlington Heights, Ill.: AMH Publishing Co., 1978.

Hetzel, Robert L. and Mehra, Yesh, "The Behavior of Money Demand in the 1980s," mimeo, October 1987.

Hoffman, Dennis and Rasche, Robert H., "Long-Run Income and Interest Elasticities of Money Demand in the United States," National Bureau of Economic Research Working Paper No. 2949, April 1989.

Johnson, Harry G., "A Quantity Theorist's Monetary History of the United States," *Economic Journal*, June 1965, *75*, 388–96.

Laidler, David, "The Rate of Interest and the Demand for Money—Some Empirical Evidence," *Journal of Political Economy*, December 1966, 74, 545–55.

———, "The Buffer Stock Notion in Monetary Economics," *Economic Journal*, Supplement, 1984, *94*, 17–33.

Lucas, Robert E., "Econometric Policy Evaluation: A Critique," *Journal of Monetary Economics*, Supplementary Series 1, 1976, 19–46.

McCallum, Bennett T., "Robustness Properties of a Rule for Monetary Policy," *Carnegie-Rochester Conference Series on Public Policy*, Carnegie Mellon University and National Bureau of Economic Research, February 1988.

Meltzer, Allan H., "The Demand for Money: The Evidence for the Time Series," *Journal of Political Economy*, June 1963, *71*, 219–46.

Moore, George R., Porter, Richard D., and Small, David H., "Modeling the Disaggregated Demands for M2 and M1 in the 1980s: The U.S. Experience," mimeo, Board of Governors of the Federal Reserve System, May 1988.

Poole, William, "Optimal Choice of Monetary Policy Instruments in a Simple Sttxhastic Macro Model," *Quarterly Journal of Economics*, May 1970, 84, 197–216.

———, "Monetary Policy Lessons of Recent Inflation and Disinflation," *The Journal of Economic Perspectives*, Summer 1988, 2, 73–100.

Rasche, Robert H., "Some Evidence on the Elusive 1982 Shift in Velocity Drift," Shadow Open Market Committee Policy Statement and Position Papers, No. 89-01, 1989, 37–40.

Tinsley, P.A. and von zur Muehlen, P., "The Reliability of Alternative Intermediate Targets," mimeo, Board of Governors of the Federal Reserve System, November 8, 1983.

Tobin, James, "Liquidity Preference as Behavior Towards Risk," *Review of Economic Studies*, 1958, *25*, 65–86.