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Monetary Targeting and Inflation: 1976-1984

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This article examines the relationship between the money supply and inflation during the period from 1976 to 1984 when monetary policy was generally framed in terms of target growth ranges for M1. Empirical evidence suggests that money supply disturbances were not an important source of inflation volatility, but that the Federal Reserve allowed such disturbances to exert a permanent effect on the level of money and prices.

Over the last 18 months, very rapid growth in M1 has been accompanied by relatively sluggish growth in nominal income. This anomaly has led many to conclude that the relationship among M1, inflation, and real income has broken down. In response to this apparent breakdown, the Federal Reserve has abandoned M1 targeting as a guide to setting monetary policy. This de-emphasis of M1 comes after a ten-year period during which monetary policy was predominantly framed in terms of growth ranges for M1.

The purpose of this article is to assess the impact of monetary policy on inflation during the period from 1976 to 1984. Monetary policy was criticized during this period both by those who opposed monetary targeting and by those proponents of targeting who opposed the Federal Reserve's tolerance of frequent, and frequently large, deviations of M1 from target. Some critics have argued that the Fed's procedure for dealing with those deviations contributed to both higher and more volatile inflation. These criticisms are empirically evaluated in this article.

The next section contains a discussion of both the Fed's procedure for setting monetary targets and the criticisms levied against that procedure. In Section II, we formulate a simple structural model linking output, prices, interest rates, and money, and discuss four hypotheses concerning the relationship between money and inflation that should be true if the criticisms were valid. The empirical methods used to evaluate these hypotheses are also presented. Section III consists of an evaluation of the empirical evidence, and Section IV provides a brief summary of the findings.

I. Monetary Targeting Since 1976

Target growth ranges for various monetary aggregates have been publicly announced by the Federal Open Market Committee (FOMC) of the Federal Reserve System since the passage of House Concurrent Resolution 133 in 1975. From the first quarter of 1976 until the passage of the Full Employment and Balanced Growth Act of 1978[1], the FOMC announced a target growth rate range for each monetary aggregate every quarter that would apply over a four-quarter period.

This target range was calculated from a base equal to the average level of the aggregate during the previous quarter. Thus, in February 1976, the FOMC set a target range of 4½ to 7 percent for M1 growth to apply to the period from 1975Q4 to 1976Q4; the range was calculated from a base equal to the average level of M1 in the fourth quarter of 1975. Three months later, the FOMC announced another four-quarter target range, in this case 4½

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percent to 7 percent again, to apply to the period 1976Q1 to 1977Q1. The base for this target range was the average level of M1 during 1976Q1.

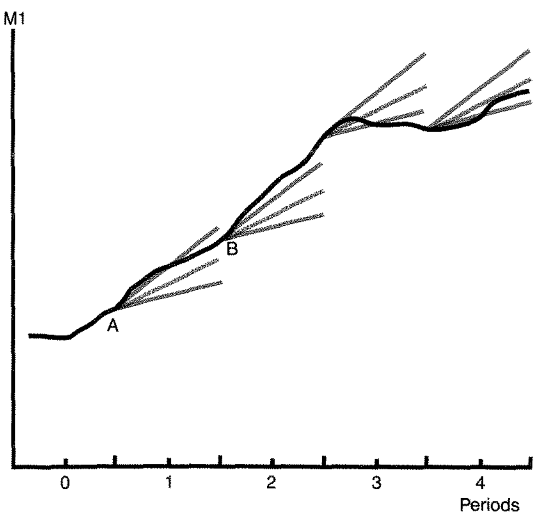
This method of setting the target growth paths for monetary aggregates leads to upward or downward shifts in those paths depending on how M1 deviates from the midpoint of its target range. A succession of hypothetical target ranges is illustrated in Figure 1. Assume that in period 1, a target range of 3 to 7 percent growth is set, with actual M1 in period 0 used as the base. This target range is represented by the cone emanating from the actual M1 value at the end of period 0 (point A in the figure). Suppose the actual path of M1 during period 1 is given by the solid line so that at the end of the period, actual M1 is given by point B. As drawn, actual M1 ended within the target cone, but above the midpoint of the cone represented by the dashed line.

In period 2, the FOMC would establish a new target growth rate range, say 3 to 7 percent again, and base the new cone on actual M1 at the end of period 1. The new target cone in the figure therefore has its apex at point B. If the solid line were to represent the actual path followed by M1, subsequent hypothetical target ranges for periods 3 and 4 would be as depicted.

Base Drift

The successive gray lines representing the midpoint of each target cone show that the procedure of using actual M1 as the base for each cone causes the base to drift upward or downward according to M1's deviation from the midpoint of any target growth cone. Such base drift has characterized the method of calculating growth targets for M1 and the broader monetary aggregates: at the beginning of each target period, the base for the new growth range has shifted to equal the actual level of money at the end of the previous target period. Base drift makes deviations of actual money from the midpoint path permanent at the end of each target period.

Figure 1
Base Drift Illustrated



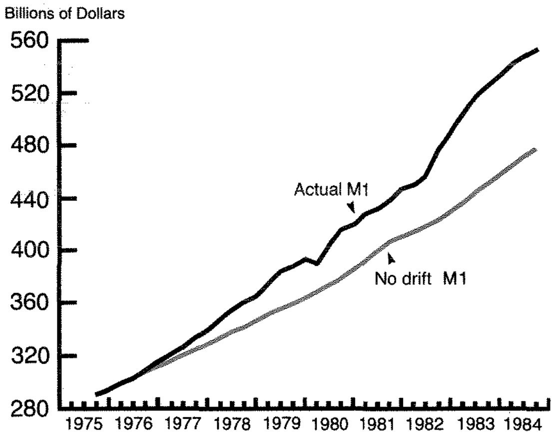
To eliminate the automatic occurrence of base drift each quarter, the Humphrey-Hawkins Act of 1978 required the FOMC to establish, in February of each year, target growth ranges for the entire calendar year. This new procedure in effect replaced automatic quarterly base drift with automatic annual base drift. That is, each February, the FOMC would establish target ranges for the fourth quarter of the previous year to the fourth quarter of the current year, calculated from a base equal to the average value of the aggregate in the fourth quarter of the previous year. Thus, in February 1979, the FOMC announced a target range of 1½ to 4½ percent growth for M1 starting from the actual value of M1 in 1978Q4.

According to the new procedure, the FOMC also reviews its target ranges at mid-year and can adjust either the base or the target growth rate ranges. For example, in July of both 1983 and 1985, the FOMC responded to rapid M1 growth during the first six months of the year by using second quarter M1 (instead of fourth quarter M1 from the previous year) as its new base for calculating growth paths and by adjusting the growth rate ranges.[2]

Chart 1 provides an estimate of the cumulative effect of base drift during the period 1976Q1 to 1985Q4 by plotting both actual M1 and a hypothetical target path that incorporates changes in the target range midpoint while maintaining actual M1 in 1975Q4 as the base. The latter series, labeled "No drift M1", shows what the path of M1 might have been if M1 growth had always been at the midpoint of the FOMC's target ranges and no base drift had been allowed. By the end of 1984, according to the No drift M1 series, actual M1 was roughly 15 percent higher than it would have been if it had always grown at the midpoint of the successive target growth rate ranges.

Chart 1

Base Drift Raises the Level of M1



There is, however, an important reason for thinking that Chart 1 may not give an accurate picture of how M1 would have behaved if the FOMC had followed a policy of preventing base drift. It has been claimed that under the federal funds operating procedure followed prior to October 1979, the Fed allowed the money stock to respond to movements in income, interest rates, and inflation. Under a different monetary policy, such as one that did not tolerate base drift, the actual behavior of these macroeconomic variables would most likely have been different. This means that the FOMC might have set different target ranges if it had eliminated base drift rather than followed its policy of allowing complete base drift.

Criticisms of Base Drift

The FOMC has frequently been criticized for allowing money growth volatility and base drift to occur. Automatic base drift implies that the growth of the money stock will have no tendency to return to a constant trend. Thus, a policy that allows automatic base drift would seem to be inconsistent with a goal of zero inflation. It has been claimed that base drift hinders the achievement of both stable money growth and stable prices over longer periods by making permanent any short-run deviations from target that occur at the end of each target period.

Broaddus and Goodfriend (1984) discuss three major objections to base drift. First, they argue that base drift reduces the public's confidence in the Fed's commitment to maintaining a stable, steady expansion of the money supply over the long-run. Second, by automatically "forgiving" any target misses, they claim base drift greatly reduces the incentives for the Fed to hit its targets. Missing a target in one year imposes no penalty on the Fed in subsequent years since each year automatically starts on target. Third, by incorporating temporary disturbances that cause money to deviate from target, they believe base drift gives those disturbances a permanent effect on the money stock and, therefore, the price level. This leads to increased uncertainty about the future price level and reduces one of the advantages of monetary targeting.[3]

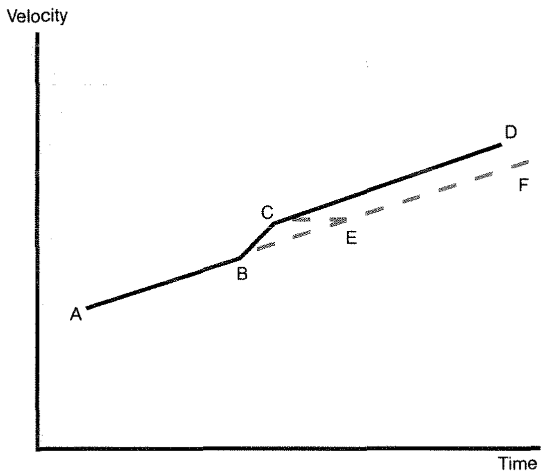
At the heart of these criticisms is the belief that the policy followed by the FOMC contributed both to raising average inflation over the ten years of monetary targeting and to increasing the volatility of inflation.

This criticism is not necessarily valid, however, since one can argue that some deviation from the midpoint target path and subsequent base drift is just what one should expect to observe if the FOMC is concerned about stabilizing inflation. For example, suppose velocity grows faster than expected during a year. If the Fed wishes to prevent such a rise from leading to higher inflation, it must reduce money growth. Consequently, the actual level of the money supply at the end of the year would be below the level implied by the midpoint target path set at the start of the year.

How should the target growth path for the next year be set? The answer to this question turns out to depend on the perceived persistence of the velocity disturbance. Suppose the unexpectedly rapid growth in velocity were temporary, with velocity growth returning to its trend value in subsequent years. The result of a one-year surge in velocity growth is to leave the *level* of velocity permanently higher, as illustrated in Figure 2 by the line ABCD. For a given path of money, such an upward shift in velocity will lead to a similar upward shift in the price level, thus generating higher inflation during the transition to a higher price level.

Higher inflation could be avoided if the path of the money supply were permanently lowered. In such a case, the FOMC should not use the midpoint of its prior year target range as the base for the next

Figure 2
A Surge in Velocity Growth Can Leave the Level of Velocity Higher



year's range because this will not produce the required lowering of the path for money. Instead, the new base should be set at a lower level. Since actual money was assumed to come in below target, the actual level of the money supply may provide a new base that would be more consistent with the prevention of a temporary increase in inflation.

A possible alternative path for velocity after an initial surge in its growth is labeled ABCEF in Figure 2. On that path, faster velocity growth is followed by an offsetting period of slower growth that returns the level of velocity to its original path (AF in the figure). In this case, no permanent adjustment in the level of the money supply is needed to prevent inflation. If the actual level of the money supply were used as the new target base, the target growth rates would have to be temporarily increased for the money supply to return to its original path. Such situations would result in a negative correlation between deviations from target midpoints and the target growth rates set for the following year as deviations of the money supply below the target path are followed by higher target growth rates designed to return the money supply to the level of the original path.[4]

Evaluation

This discussion suggests that the impact of M1 deviations from the target midpoint growth path on inflation will depend on the reasons for the deviation. On the one hand, such deviations might arise because the Fed allows the money stock to respond to income, interest rate, or inflation movements caused by disturbances to the economy. As was pointed out in the discussion of a velocity disturbance, the appropriate monetary policy response depends crucially on the nature of the initiating disturbance. Shocks likely to persist call for a different policy response than do more transitory disturbances.

On the other hand, some M1 target misses may represent the effects of money stock control errors or policy actions unrelated to income, inflation, or interest rates. Such money supply disturbances will change output and inflation; they represent an independent source of inflation volatility that can be attributed to monetary policy.

To evaluate the impact of monetary policy on inflation, then, it is necessary to answer two questions. First, have money supply disturbances been an important source of inflation volatility? Second, has the induced policy response of the money supply to economic disturbances contributed to the inflationary impact of such disturbances? If the answer to these questions is "yes", and the behavior of the money supply during the period of monetary targeting has contributed to inflation uncertainty and volatility, the following four stylized "facts" should characterize the data:

1. Money supply disturbances should account for a significant fraction of the volatility of inflation;
2. Changes in money growth should lead to subsequent movements in the rate of inflation;
3. Knowledge of money growth should help to forecast future inflation;
4. Temporary spending or money demand disturbances should lead to persistent, or permanent, responses of the money supply.

The data should have the first three of these four characteristics if independent money supply disturbances arising from policy shifts or from the failure to control the money supply were important contributors to inflation volatility. The fourth characteristic would be true if the Fed has responded to economic disturbances in a manner that has contributed to raising the average rate of inflation.

To determine whether these stylized facts hold for the U.S. during the period of monetary targeting, it is necessary to translate each into a statistical hypothesis that can be tested. This translation will be done within the context of a simple structural model linking money with other macroeconomic variables. This model is discussed in the next section.

II. Empirical Framework

This section discusses an empirical framework that can shed light on the criticisms levied at the FOMC's conduct of monetary policy. The model to be examined consists of four variables: real GNP in 1982 prices, the GNP price deflator, the three-month Treasury bill rate, and M1. (All observations are quarterly.) Because most macro variables are nonstationary, the analysis is carried out in terms of first differences. Let Y_t, P_t, and M_t denote the first differences of the log of real GNP, the price deflator, and M1, respectively. Thus, Y, P, and M are approximately equal to the quarterly growth rates of output, prices, and money respectively. Let R_t denote the first difference of the level of the bill rate. All variables are expressed at seasonally adjusted annual rates.

A simple four-equation model was used to capture the structural relationships assumed to hold among the equilibrium values of these macro variables. The first equation is a simple IS, or aggregate spending, relationship that assumes real aggregate spending depends on the anticipated real rate of interest. This is represented by equation 1:

$$Y_t = \alpha_1(R_t + P_t - E_tP_{t+1}) + W_{1t-1} + u_{1t} \qquad (1)$$

where E_tP_{t+1} is the expectation of P_{t+1}, so that $R_t + P_t - E_tP_{t+1}$ is the expected real rate of interest, and W_{1t-1} is a composite term that incorporates all the dynamic effects of past values of income, prices, interest rates and money on Y_t. Since an increase in the expected real rate of interest should reduce aggregate spending, α_1 should be negative. The disturbance term u_{1t} will be referred to as an aggregate demand shock; it captures all contemporaneous effects on Y_t other than those operating through the real interest rate.

The second structural equation is a simple Phillips curve or aggregate supply relationship;

$$P_t = \alpha_2 Y_t + W_{2t-1} + u_{2t} \qquad (2)$$

Again, W_{2t-1} captures the effects of all lagged values and so would also incorporate the impact on P_t of expectations of P_t formed in earlier periods. The coefficient α_2 should be positive, as, ceteris paribus, a rise in output should lead to a rise in the price level. The disturbance term u_{2t} represents an aggregate supply shock.

The third structural equation in the model specifies the demand for real money balances as dependent on income and the nominal interest rate as well as on lagged values of the variables in the model:

$$M_t - P_t = \alpha_3' Y_t + \alpha_4' R_t + W_{3t-1}' + u_{3t}'.$$

For the purpose of estimation, this equation is normalized on the interest rate and written as

$$R_t = \alpha_3 Y_t + \alpha_4(M_t - P_t) + W_{3t-1} + u_{3t}. \qquad (3)$$

Since a rise in output should increase the demand for real money balances whereas a rise in the nominal rate should reduce it, we expect α_3 to be positive and α_4 to be negative. The disturbance term u_{3t} represents a money demand shock.

The final equation of the structural model is a description of money supply determination:

$$M_t = \alpha_5(Y_t + P_t) + \alpha_6 R_t + W_{4t-1} + u_{4t}. \qquad (4)$$

Equation 4 relates the money supply to the contemporaneous value of nominal income and the nominal interest rate. As in the other equations, W_{4t-1} captures any lagged effects on money supply. If the Federal Reserve slows money growth when nominal income growth increases, α_5 would be negative. However, Fed critics have often charged that the Fed allows money growth to vary procyclically. This would suggest that α_5 may be positive. Since it is also often claimed that the Fed "leans against the wind" by attempting to smooth interest rate movements, α_6 would be expected to be positive. The term u_{4t} represents a money supply shock; it incorporates all contemporaneous influences on the money supply except the influences of nominal income and interest rates.

This structural model allows money supply effects to operate through three channels. First, u_{4t} represents monetary disturbances that directly affect the money supply and, through the presence of M in equation 3, interest rates, output, and prices. Second, aggregate spending, aggregate supply, and money demand shocks will affect nominal income and the nominal rate of interest, and thereby cause the money supply to respond endogenously, as long as α_5 and α_6 in equation 4 are not both zero. Third, lagged values of the money supply will also have effects on current output and prices. Empirical estimates of these various channels can be used to shed light on the stylized facts listed in the previous section.

Statistical Hypotheses

Within the context of the model described, stylized facts numbers 1 and 2 can both be interpreted as statements about the effects of money supply disturbances on inflation. Evidence that money supply shocks account for a large fraction of the variance of inflation would support "Fact" 1. Likewise, "Fact" 2 would be supported by evidence that a nonzero realization of the money supply shock led to subsequent movements in inflation.

To cast light on stylized fact 3, the four structural equations can be solved to express Y_t, P_t, R_t and M_t as functions of the lagged values of these variables and the current values of the structural disturbances. "Fact" 3 can then be interpreted as a statement about the coefficients on past values of M. If the coefficients on lagged M in the equation for inflation are jointly zero, then knowledge of past money supply growth rates does not help in forecasting inflation once past inflation, output, and interest rates are taken into account. Hence, nonzero coefficients on past M would provide evidence in favor of "Fact" 3.

Evidence relevant for judging "Fact" 4 can be obtained by determining how the money supply responds to disturbances to the model. Since disturbances in the structural model are assumed to be serially uncorrelated, a finding that *temporary* shocks to, for example, money demand had *persistent* effects on the money supply and prices would indicate that the induced response of the money supply to economic conditions was leaving lasting effects on prices and contributing to inflation as the price level adjusts.

Although it will be argued below that "Fact" 3 is the least interesting of the three stylized facts, it is the easiest to test since an estimate of the effects of lagged M on P can be obtained by directly regressing P on lagged values of M, Y, P, and R. However, to assess "Facts" 1, 2 and 4, it is necessary to recover information on the true structural disturbances, and this requires first estimating the α_is that characterize the contemporaneous relationships among Y, R, P and M.[5]

III. Empirical Results

The empirical results reported here are all based on the sample period 1977Q1 - 1984Q4. This period encompasses several changes in Federal Reserve operating procedures, the most important of which was the move, in October 1979, from a federal funds operating procedure to a nonborrowed reserves procedure. The Fed's commitment to monetary targeting also seems to have varied over this period. Unfortunately, the shortness of the sample period precludes dealing adequately with these potential structural shifts. Nevertheless, estimates derived from the whole sample may still provide useful information about the average impact of monetary shocks.[6]

Estimated values of the parameters giving the contemporaneous relationships between Y, R, P, and M in the structural model are listed in Table 1. All parameter signs agree with prior expectations, and, with the exception of the real interest elasticity of aggregate spending (α_1), all the parameters are

TABLE 1

Parameter Estimate for Structural Model

Parameter	Estimated Values	Standard Error*
α_1	−0.48	0.85
α_2	0.19	0.07
α_3	0.24	0.03
α_4	−0.56	0.04
α_5	−0.11	0.06
α_6	3.39	0.09
Variance of u_1	.00072	.00028
Variance of u_2	.00007	.000004
Variance of u_3	.00013	.00001
Variance of u_4	.00034	.00001

*These are asymptotic standard errors; see Hansen and Singleton [1982] for the appropriate formula.

statistically different from zero at conventional significance levels. Of particular interest is the estimated equation for the money supply — equation 6. The negative estimated value of α_5 — the coefficient on nominal income — indicates some endogenous policy response within the quarter to offset contemporaneous movements in nominal income. However, the very large coefficient estimate for α_6 is evidence of a tendency to attempt to offset nominal interest rate movements.

The estimated variances of the structural disturbance terms allow some conclusions to be drawn about their relative importance in generating economic fluctuations. In decreasing order of size are the variances of aggregate spending shocks, which are estimated to be more than twice as large as any of the other variances, money supply shocks, money demand shocks, and aggregate supply shocks. This ordering is somewhat at variance with the traditional Federal Reserve view that emphasizes the importance of money demand shocks. However, u_3 was the disturbance for a money demand equation normalized on the interest rate. When converted back to the standard form of a money demand equation, the estimated variance is .00052. This results in a ranking that seems consistent with the Federal Reserve view.

The estimated coefficients of the structural model, together with the results of the vector autoregression (VAR) estimation technique used to estimate the effects of lagged variables on Y, R, P and M, can be used to study the impact of money on the macroeconomy during the period of monetary targeting. In particular, it is possible to examine the stylized facts about monetary policy that were discussed in Section II.

If independent monetary volatility has contributed to the volatility of inflation, then one should expect to find that money supply disturbances, as identified in the structural model, account for a large fraction of the variance of errors made in forecasting future inflation. Table 2 presents the decomposition of the forecast error variance for inflation. Each column reports the fraction of the total variance of the inflation forecast error that is attributed by the structural and VAR estimates to a particular structural disturbance.[7] Results for various forecast horizons ranging from one quarter to 24 quarters are reported.

The clear conclusion from Table 2 is that money supply disturbances contribute very little to inflation uncertainty as measured by the variance of forecast errors. The evidence from this variance

TABLE 2

Variance Decomposition of Inflation

Quarter	Aggregate Spending	Aggregate Supply	Money Demand	Money Supply
1	24.15	75.78	0.03	0.04
4	18.64	73.42	6.35	1.59
8	22.66	65.19	9.16	2.99
12	22.41	64.96	9.34	3.29
24	22.18	64.36	10.04	3.43

decomposition suggests that the first of the four stylized facts discussed in Section II is not an accurate description of the money supply-inflation relationship during the period of monetary targeting.

To gauge whether shocks to the supply of money lead to subsequent movements in the rate of inflation — stylized fact 2 — the VAR and structural model estimates can be used to calculate the impact of a money supply disturbance both directly on each of the model's variables and indirectly through the induced effects of changes in one variable on the others. Table 3 presents the responses of all four variables in the model to a money supply disturbance.

The immediate impact of a positive shock to the growth rate of the money supply is a decline in market interest rates, a rise in real output growth, and an increase in the rate of inflation. However, the impact on the rate of inflation is very small, peaking 6 quarters after the shock to money growth, and then declining. This evidence, which is consistent with the variance decompositions reported in Table 2, suggests that money supply disturbances do not have large effects on subsequent inflation. As the last column of Table 3 shows, the small impact is in large part due to the temporary nature of the effect of money supply shocks on the rate of growth of the money supply.

An alternative way to assess the impact of monetary changes on future inflation involves testing whether information about past money growth rates is helpful in predicting the rate of inflation once past inflation rates, output growth rates, and nominal interest rates are known.[8] In essence, such a test examines whether monetary changes precede changes in inflation. The structural model is not needed to carry out such a test since, as explained in Section II, the test involves only the statistical significance of the coefficients on lagged money growth rates in the VAR equation for the rate of inflation. The relevant F-statistic for this test is 0.30 with a marginal significance level of 87 percent. Thus, the data are quite consistent with the hypothesis that money does not help to forecast inflation.

This test result, however, is not particularly useful for evaluating the contribution of money supply disturbances to the level and volatility of inflation. For example, the evidence that past money growth does not aid in forecasting inflation once past inflation, real output growth, and nominal interest rates are known is entirely consistent with the hypothesis that monetary shocks have a large contemporaneous impact on inflation. It is also consistent with the view that nonmonetary disturbances have been the cause of most inflation fluctuations over the period studied.

The results in Tables 2 and 3 indicate that money supply disturbances do not constitute an important source of independent variation in inflation. Yet this result in still consistent with the criticism that the FOMC has let the money supply respond endogenously to interest rates and income in a manner that has led to more inflation than would have occurred under a policy that eliminated such induced movements of the money supply. To assess

TABLE 3

Responses to a One-Standard Deviation Money Supply Disturbance*

Quarter	Y Output Growth	P Inflation	R Changes in Interest Rate	M Money Growth
1	0.11	0.02	−0.34	0.66
4	−0.10	0.10	−0.06	−0.92
8	−0.22	0.01	0.09	−0.11
12	0.13	0.03	0.11	−0.14
24	−0.00	0.02	−0.02	−0.04

*All entries have been multiplied by 100.

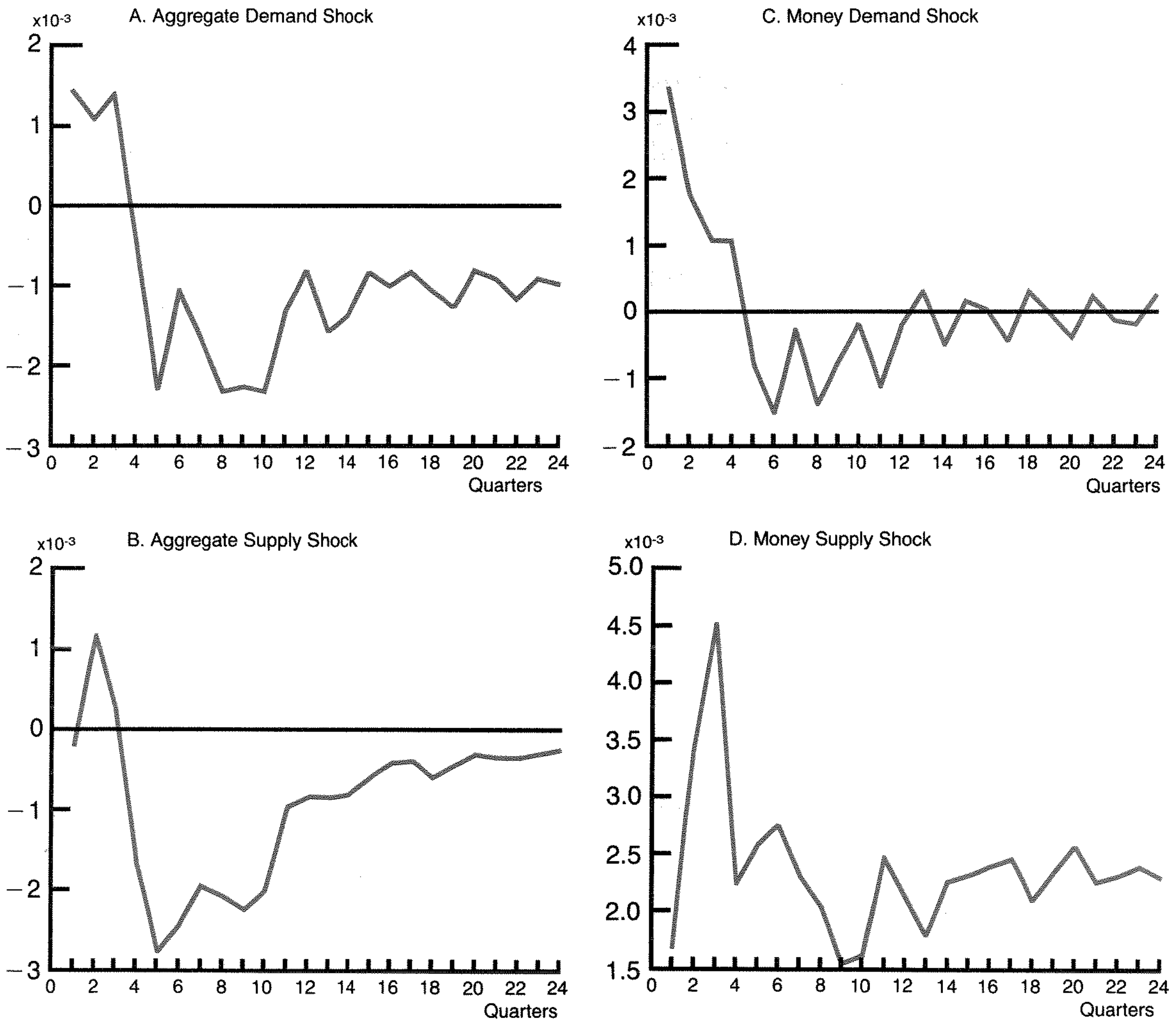
this criticism, it is necessary to examine the manner in which the money stock responds to the other disturbances in the model. The response of the *level* of M to each of the various structural disturbances is reported in Chart 2.

Several interesting conclusions are apparent from Chart 2. Panel A shows the response of the level of the money supply to an aggregate spending disturbance. Initially, the money supply responds positively to a spending increase, but this is reversed by the end of four quarters. The net effect of the aggregate spending shock is to leave the level of the money supply lower than it would have been in the absence of the positive spending shock. The pattern of response to an aggregate supply shock, shown in Panel B, is similar. The net effect of an aggregate supply shock on the level of the money supply, however, is more than offset within a year. Eventually, the path of the money supply appears to return to what it would have been in the absence of the shock.

In Panel C, the response of the money supply to a money demand shock is illustrated. A positive money demand disturbance induces an increase in money growth that appears to be fairly quickly reversed. At the end of five quarters, the level of the money supply is back to where it would have been had it remained on its initial path.

Chart 2

Response of Money to Various Shocks



In none of these first three panels is there evidence that aggregate spending, aggregate supply, or money demand shocks induce permanent effects on either the growth rate of the money supply, or even the level of the money supply, that would produce sustained inflation.[9]

Panel D paints a somewhat different picture. A positive shock to the money supply is not completely offset afterward. Instead, the shock leaves the nominal money supply permanently higher. This implies that money supply disturbances do seem to have the effect of permanently raising the price level, and, during the transition to a higher price level, producing an increased rate of inflation. This evidence is consistent with Table 3 which showed that money supply shocks led to a period of temporarily higher inflation. Because these shocks are never offset, the price level is left permanently higher.

One interpretation of these results is that the FOMC lets temporary errors in its control of the money supply result in permanent changes in the price level. This interpretation supports the criticism of automatic base drift — that base drift converts temporary deviations (due to control errors) from the target path into permanent deviations of the price level from the path consistent with a constant rate of inflation.

IV. Summary and Conclusions

This article has examined the relationship between the money supply and inflation during the period from 1976 to 1984 when monetary policy was generally framed in terms of target growth ranges for M1. The major criticisms of the Federal Reserve's loose control of the money supply focused on the implications of money growth for inflation.

To assess the empirical validity of these implications, evidence obtained from a vector autoregression and an estimated structural model was employed. The empirical sections of the paper examined the impact of money supply shocks on subsequent inflation, the fraction of inflation forecast error attributable to money supply shocks, the contribution of past money growth to the forecast of inflation, and the induced response of money to aggregate spending, aggregate supply, money demand, and money supply disturbances.

In general, little evidence was found to indicate that money supply disturbances have independently made a major contribution to the level of inflation or its unpredictability. However, it does appear that the FOMC has allowed random disturbances in the growth rate of the money supply to exert a permanent effect on the level of money and prices. Faster-than-expected money growth generates temporarily higher inflation that leaves prices permanently higher. Such a finding is not surprising given the FOMC's policy of automatic base drift, in which deviations of the money supply from target are allowed to affect the level of the money supply permanently. However, given the short sample period and the changes in Federal Reserve operating procedures that occurred in 1979 and 1982, these conclusions must be considered tentative.

FOOTNOTES

1. This Act is better known as the Humphrey-Hawkins Act.

2. Each year, the Federal Reserve Bank of St. Louis publishes in its *Review* an analysis of the FOMC deliberations on setting targets during the previous year.

3. The Shadow Open Market Committee (1985) has recommended the elimination of base drift. See also M. Friedman (1982, 1985) and McCallum (1984). In one of the earliest attacks on base drift, Poole (1976) suggested, as an alternative procedure, that the midpoint of the previous year's target range, and not actual M1, be used as the new base. This recommendation was also proposed in the 1985 *Economic Report of the President*.

4. In fact, this correlation is positive. For a more detailed analysis of base drift, see Walsh (1986).

5. Actual estimation proceeds in two steps. If Z_t is the column vector of Y_t, P_t, R_t, M_t, then the structural model can be written as $AZ_t = B(L)Z_{t-1} + u_t$. Hence, $Z_t = A^{-1}B(L)Z_{t-1} + A^{-1}u_t = D(L)Z_{t-1} + v_t$. The lag coefficients in D(L) can be obtained in the first step from estimating a vector autoregression (VAR) in Z_t. This also yields estimates of v_t. A lag length of four was used in the VAR and each equation also included a constant and a time trend. In the second step, an estimate of A was obtained by noting that the population covariance matrix of v is $A^{-1}\Sigma_u A^{-1\prime}$ where $\Sigma_u = E(u'u)$ and applying a Generalized Methods of Moments estimation procedure. For further discussion of this approach, see Bernanke [1986] or Sims [1986]. The Generalized Methods of Moments estimator is discussed in Hansen and Singleton (1982) and Chamberlain (1984). The structural disturbances can then be recovered as $\hat{A}\hat{v}_t$ where $\hat{A}$ is the estimate of A and $\hat{v}_t$ is the vector of VAR residuals. See also Walsh [1987].

6. In Walsh (1987), the model was expanded to include a measure of the Fed's M1 target and a dummy variable for the period 1979Q4 to 1982Q3, when the Fed used a nonborrowed reserves operating procedure. This slight change in the specification had a large impact on the estimated dynamics implied by the VAR system. Points where the results of this paper differ from those of Walsh (1987) are noted in footnote 9.

7. Unlike standard methods of orthogonalizing the VAR residuals to construct variance decompositions, the approach taken here, which combines a VAR with a structural model, yields results that are independent of the ordering of the variables. Thus, the fact that money supply shocks are listed last in Table 2 has no significance.

8. This is just a test of the null hypothesis that money does not Granger cause inflation.

9. Somewhat different results were obtained from an extended model that included a dummy variable for 1979Q4 to 1982Q3. In this model, aggregate supply shocks appear to produce a permanent increase in the rate of money growth. This indicates that the endogenous Federal Reserve policy response contributed to the inflationary impact of aggregate supply disturbances. See Walsh, (1987).

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