MONEY GROWTH VOLATILITY AND HIGH NOMINAL INTEREST RATES

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On October 6, 1979, the Federal Reserve announced a change in its operating procedures aimed at improving control of the monetary aggregate M1. Since then, however, M1 growth has become highly volatile.[1] Furthermore, the increased volatility of money growth was accompanied early by increased levels as well as volatility of nominal interest rates. Nominal interest rates rose and remained at significantly high levels through mid-1984, despite the sharp reduction in actual inflation which occurred between 1979 and 1982. Since mid-1984, however, nominal interest rates have declined significantly.

Some analysts contend that the high nominal interest rates of the 1979-86 period were due to increased volatility of money growth[2] caused by the Federal Reserve's new operating procedures. The main argument is that the increased money growth volatility induced by policy raised uncertainty about the direction of Federal Reserve monetary policy. A rise in uncertainty resulted in an increased demand for money which—in the absence of an accommodative Federal Reserve policy—caused nominal interest rates to rise. Nominal interest rates have declined sharply since mid-1984, even though M1 growth continues to be highly variable. This argument, if correct, attributes such a decline to a more accommodative Federal Reserve monetary policy stance adopted since then.

This article reexamines the foregoing hypothesis. The period since 1979 has been marked by a new round of financial deregulation including the introduction nationwide of interest-bearing NOWs in 1981 and Super NOWs in 1983. It is now widely recognized[3] that these developments may have played an important role in causing shifts in money demand and in raising the volatility of money growth over the 1980s. Hence, when testing the validity of the hypothesis of money growth volatility, it is essential to control for such effects of financial deregulation.

The empirical work reported here suggests that not all of the increase in the volatility of M1 growth should be attributed to Federal Reserve operating procedures. The recent round of financial deregulation has caused shifts between the types of assets the public wants to hold, shifts manifested by movements into and out of M1 that made M1 growth more volatile. Evidence supports this conclusion; for while the volatility of M1 did increase significantly after the change in procedures, the volatility of a broad monetary aggregate, M2 or M3, was not significantly greater than before. If all of the increased volatility of M1 growth was policy-induced, the volatility of M2 and M3 also should have increased, ceteris paribus.

It is also concluded that money growth volatility does not exert an independent influence on the public's demand for real money balances, so that the increased volatility of M1 growth did not contribute to high nominal interest rates through the money demand channel. Nevertheless, M1 demand has shifted upward during the 1980s, and the major source of this shift appears to be financial deregulation. Hence, high nominal interest rates observed early in the 1979 to 1986 period could have been caused in part by an increase in the demand for money. Apparently, too, deregulation has raised the magnitude of the response of the nominal interest rate to expected inflation, which could explain part of the high levels of nominal interest rates observed in recent years.

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[1] In the late fall of 1982, the Federal Reserve again modified its operating procedures. The volatility of M1 growth has declined somewhat since then. However, M1 growth has remained quite variable during the 1982 to 1986 period.

[2] Mascaro and Meltzer (1983) and Hall and Noble (1987).

[3] Simpson (1984), Mehra (1986), Kretzmer and Porter (1986), Wenninger (1986), Trehan and Walsh (1987), and Hetzel and Mehra (1987).

The remainder of the article contains an evaluation of the money growth volatility hypothesis and the empirical results that underlie the conclusions reached here.

I.
Money Growth Volatility Hypothesis

This section presents and evaluates the money growth volatility hypothesis.

Background

Analysts who contend that the Federal Reserve's new operating procedures caused money growth to be highly volatile usually point to a sharp increase in the variability of M1 growth since 1979. As shown in Chart 1a, the variability increased sharply between 1979Q4 and 1982Q2, declined somewhat thereafter, and has remained high since then.[4] Chart 2 depicts the behavior of the nominal interest rate over the same period. As shown in Chart 2, the nominal interest rate, measured here by the yield on one-year Treasury bills, rose to high levels between 1979 and 1982 when the new monetary control procedures were in force. The nominal interest rate persisted at fairly high levels through the first half of 1984 and since then it has trended downward. It is a widely held view that the behavior of the nominal interest rate since 1979 could not be readily predicted from its past relationship with inflation, money growth, cyclical pressure, and fiscal policy variables.[5]

Money Growth Volatility Hypothesis Stated

Mascaro and Meltzer (1983) instead have attributed the above noted behavior of nominal rates to an increase in the degree of monetary instability, which, they allege, was caused by the Federal Reserve's new monetary control procedures. They reason that in a less stable, more variable environment, people choose to hold more money and less of other assets such that there is a positive associ-

[4] Variability is here defined as the eight-quarter moving average of the standard deviation of quarterly growth rates of actual money stock. This measure is similar in spirit to measures used in other studies although some of those deal with unexpected portions of the growth rate of the money stock.

[5] For example, Clarida and Friedman (1984) using a vector autoregression model reach the conclusion that short-term interest rates in the United States have been "too high" since October 1979. The standard estimated Fisher-type interest rate regressions used in several interest rate studies, including Wilcox (1983), Peek (1982), Tanzi (1980), and Makin (1983), tend to underpredict the nominal interest rate in the post-1979 period.

Chart 1a

VARIABILITY OF M1 GROWTH*

1963-1986

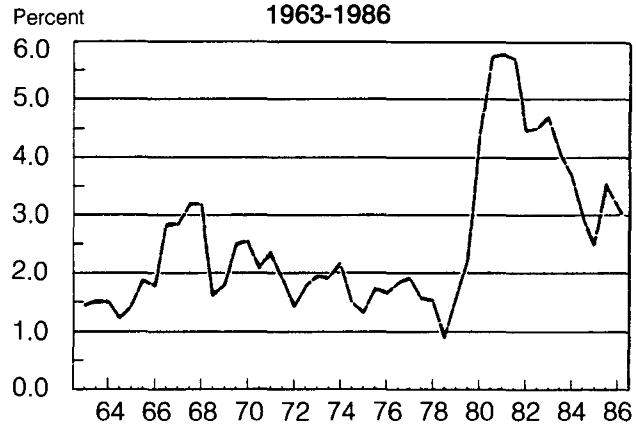


Chart 1b

VARIABILITY OF M2 GROWTH*

1963-1986

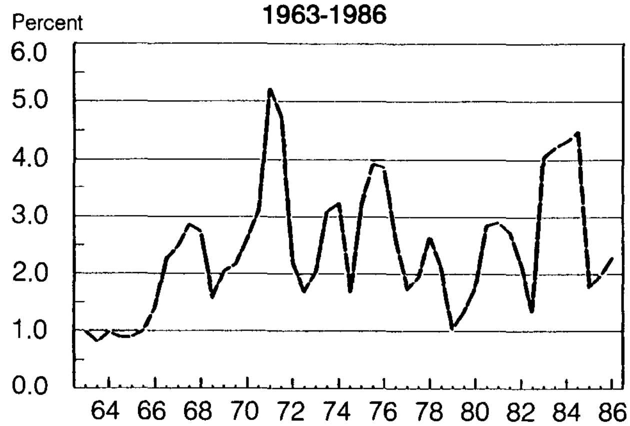
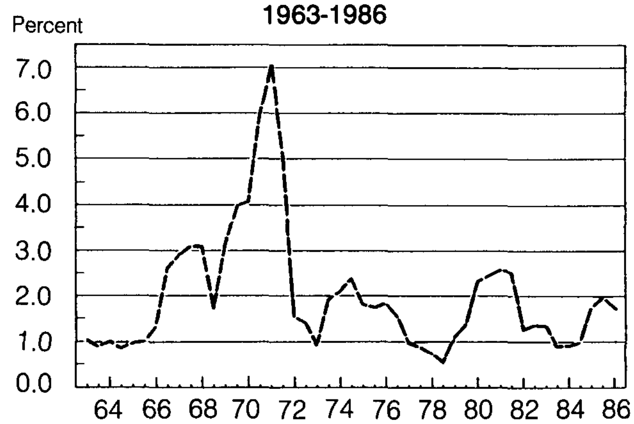


Chart 1c

VARIABILITY OF M3 GROWTH*

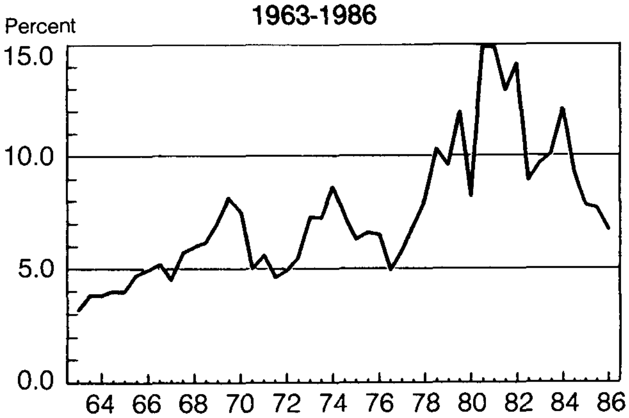
1963-1986



* Variability of money growth is measured as the eight-quarter moving average of the standard deviation of quarterly growth rates of actual money stock.

Chart 2

NOMINAL INTEREST RATE ONE-YEAR TREASURY BILL RATE 1963-1986



ation between variability and the demand for money. Assuming further that an increase in the demand for money raises short-term nominal interest rates, it follows that there is also a positive association between monetary variability and the level of the nominal interest rate.

The assumptions which underlie their hypothesis can be clarified further using the IS-LM model. Consider first the simple IS-LM model which contains two assets—money and capital—and in which the demand for money depends positively upon the degree of monetary instability. In such a model an increase in the degree of monetary instability raises money demand which, in turn, results in a higher short-term nominal interest rate, provided the real supply of money remains fixed. The latter assumption implies either that the price level does not adjust or that the Federal Reserve does not accommodate the increase in money demand.

In case there are more than two assets, the effect of an increase in the degree of monetary instability on short-term interest rates is ambiguous. Mascaro and Meltzer (1983) consider the IS-LM model in which there are three assets—money, short-term bonds, and capital. If one continues to assume that the demand for money depends positively on the degree of monetary instability, then increased instability could cause people to hold more of both money and short-term bonds that are close substitutes for money. In that case, even though an increase in the demand for money raises the short-term interest rate, higher demand for substitute short-term bonds depresses the nominal interest rate, so that the net impact of an increase in the degree of monetary instability on the short-term rate is uncertain.

The empirical work reported in Mascaro and Meltzer, however, shows that the short-term nominal rate does rise in response to an increase in the variability of M1 growth. Moreover, they also report evidence suggesting a positive association between the variability of M1 growth and the demand for money.

Criticism of the Money Growth Volatility Hypothesis

The major objection to the money growth volatility hypothesis questions the empirical validity of the underlying assumptions of (1) a positive association between degree of monetary instability and demand for money, and (2) the supposition that the increased monetary instability was due entirely to the Federal Reserve's monetary policy operating procedures. The empirical evidence supporting these assumptions is not very persuasive because it does not control for the potential effects on money demand of financial deregulation.

An alternative hypothesis receiving considerable support in several recent money demand studies, including Simpson (1984), Mehra (1986), Kretzmer and Porter (1986), Trehan and Walsh (1987), and Hetzel and Mehra (1987), is that M1 demand has been stronger and more volatile in the 1980s than before because M1 now contains interest-bearing assets such as NOWs and Super NOWs. The inclusion in M1 of NOWs and Super NOWs has reduced the opportunity cost of holding money, thereby inducing the public to hold more of it. Moreover, the public has also been willing to substitute more than before between the interest-bearing deposits included in M1 on the one hand and the substitute, savings-type deposits included in M2 and M3 on the other.

A bit of evidence that supports the above mentioned shifts in money demand is reproduced below. It consists of out-of-sample prediction errors of the conventional money demand regression that uses alternative measures of money—M1, M2, and M3. A standard money demand regression that uses these measures is estimated over the common sample period 1963Q1 to 1979Q3 and simulated out-of-sample over 1979Q4 to 1986Q4. The resulting errors are reported in Table I. The percentage error in predicting the level of nominal money demand is reported in columns A1, and the error in predicting its quarterly growth rate is reported in columns A2 (only second- and fourth-quarter observations are reported). RMSE statistics are also reported in Table I. For M1, prediction errors are large and positive and the RMSE value is high, implying that M1 demand had been strong and highly variable in

Table I

Simulation Results, Percentage Error in Predicting Nominal Money Demand

Quarterly Data 1979Q4 to 1986Q4

Measure of Money Used in the Money Demand Regression

Year/Quarter	M1 A1 Level	M1 A2 Quarterly Growth Rate	M2 A1 Level	M2 A2 Quarterly Growth Rate	M3 A1 Level	M3 A2 Quarterly Growth Rate
1979Q4	-.4	-1.5	-.0	-.0	.2	.8
1980Q2	-2.9	-10.6	-.0	-4.1	-.9	-5.1
1980Q4	-1.5	1.1	-.6	-1.5	-1.0	-.1
1981Q2	-1.9	1.9	.6	5.4	.5	2.9
1981Q4	-3.5	-.8	.0	.7	.8	1.2
1982Q2	-2.5	1.3	1.6	2.7	2.5	3.9
1982Q4	.7	10.9	2.9	1.0	3.9	.7
1983Q2	3.5	6.4	5.7	.9	4.1	-.6
1983Q4	4.7	.0	4.9	-1.8	3.5	-1.8
1984Q2	4.4	1.1	3.5	-1.1	3.2	.8
1984Q4	4.4	-.0	3.9	1.6	3.9	2.0
1985Q2	6.6	4.9	3.3	-3.9	2.6	-4.6
1985Q4	10.6	5.6	3.0	-2.3	1.9	-1.8
1986Q2	15.4	11.9	3.2	2.4	2.3	1.3
1986Q4	22.6	14.2	4.0	2.5	2.5	1.4
RMSE	7.6	5.9	3.1	3.0	2.6	2.3

Notes: The values reported in columns A1 above are the percentage errors in predicting the level of the nominal money demand, whereas those reported in columns A2 are the (annualized) quarterly growth rate errors (only second- and fourth-quarter observations are reported). The predicted values are from the money demand regressions estimated over 1963Q1 to 1979Q3. The underlying money demand regression is of the form

$$\ln(M_t/P_t) = a + \sum_{s=0}^{3} b_s \ln y_{t-s} + \sum_{s=0}^{3} c_s \ln R_{t-s} + D74$$

where M is either M1 or M2 or M3, y is real GNP, R is the 4-6 month commercial paper rate, and P is the implicit GNP deflator. Estimation is by Hildreth-Lu procedure, and simple distributed lags are used. D74 is the zero-one dummy variable, taking values 1 in 1974Q2-1976Q4 and zero otherwise. RMSE is the root mean squared error, calculated using the errors over the 1979Q4 to 1986Q4 period.

the 1980s. However, there is a sharp reduction in the magnitudes of prediction errors if M2 or M3 is used. For example, the RMSE values of the quarterly growth rate prediction errors are *5.9, 3.0,* and *2.3* percent for M1, M2, and M3, respectively. These estimates, therefore, support the presence of increased substitutions by the public between assets included in M1 on the one hand and M2 and M3 on the other.

The alternative explanation of M1 demand behavior has several implications for the validity of the money growth volatility hypothesis. First, one may find divergence in the volatility of monetary aggregates. Deregulation-induced substitutions could produce an increase in the volatility of M1 growth accompanied by little or no change in the volatility of broad aggregates.[6] This is confirmed further by

[6] Formally, this point can be explained as follows. Consider the following expressions for the variance of the broad aggregates

$$\text{Var M2} = \text{Var M1} + \text{Var (M2-M1)} + 2\ \text{COV (M1, M2-M1)} \quad (a)$$

$$\text{Var M3} = \text{Var M1} + \text{Var (M3-M1)} + 2\ \text{COV (M1, M3-M1)} \quad (b)$$

where (M2 - M1) is the non-M1 component of M2; (M3 - M1), the non-M1 component of M3; Var, the variance; and COV, the covariance of the relevant variables. If the increase observed in the variance of M1 is policy-induced, then variances the evidence reported in Charts 1b and 1c and Table II. Charts 1b and 1c display the variability of broad aggregates, M2 and M3, and Table II reports mean standard deviation values of money growth computed over the two sample periods, 1961Q1 to 1979Q3 and 1979Q4 to 1986Q4. As can be seen by comparing Charts 1a through 1c, the broad measures of money—M2 and M3—have not since 1979 displayed the variability of the M1 measure. The same is true if one compares the mean standard deviation values reported in Table II.[7]

The implication of all this is that not all of the increase observed in the variability of M1 growth should be attributed to the adoption by the Federal Reserve of new monetary control procedures. A part has been due to an increase in the variability of M1 demand.

A second implication is that the money growth volatility hypothesis should be reexamined using broad measures of money. The broad measures of money are likely to internalize the above mentioned deregulation-induced substitutions. Hence they should provide a sharper test of the joint hypothesis that the increased volatility of money growth was policy-induced and contributed to high nominal interest rates via raising money demand.

If financial deregulation is at the source of the observed strength in money demand, then another important consequence is a potential increase in the magnitude of the response of the nominal interest rate to inflation. The basic argument here is as follows. Most empirical studies of interest rate determination have found that fully anticipated inflation has less than a one-for-one effect on the nominal interest rate. Thus, expected inflation reduces real rates of return on financial assets (bonds). Some analysts attribute this result to the existence of legal restrictions on the payment of explicit interest on money.[8] According to their argument, optimizing individuals tend to hold money and financial assets to the point at which their (after-tax) yields are equal. Inflation reduces the equilibrium real rate of return on money, which, in the presence of the prohibition of the payments of explicit interest on money, is just the negative of the rate of inflation. If one assumes further that financial assets are closer substitutes for money than for capital,[9] then an inflation-induced fall in the equilibrium real rate of return on money forces a corresponding fall in the real rate of return on financial assets as investors substitute out of money into financial assets.

The introduction nationwide since 1981 of interest-bearing NOWs, Super NOWs, and Money Market Deposit Accounts together with the gradual lifting in recent years of the remaining regulatory interest rate restrictions on several components of money and money substitutes[10] means that a rise in anticipated inflation does not reduce equilibrium real rates of return on money and money substitutes as much as it did before. The presence of this effect tends to enhance the response of the nominal interest rate to expected inflation.

Table II

Volatility of Monetary Aggregates
Mean Values of the Standard Deviation of Quarterly Growth Rates

Sample Period	Monetary Aggregate M1	M2	M3
1961Q1-1979Q3	1.88	2.18	2.10
1979Q4-1986Q4	4.15	2.73	1.67

Notes: Volatility is defined as the eight-quarter moving average of the standard deviation of quarterly growth rates of actual money stock. The values reported above are mean values of the standard deviation of monetary aggregates.

of the broad measures of money should also increase. However, if part of the increase observed in the variance of M1 is due to increased substitution by the public between assets included in M1 on the one hand and assets included in (M2 − M1) or (M3 − M1) on the other, then the broad measures—M2 and M3—should be relatively less variable, as higher variance terms in (a) and (b) above are offset by large, negative covariance terms.

[7] Two aspects of this data, reported in Table II, warrant underscoring. First, whereas the mean values of the standard deviation of broad measures of money exceeded that of the narrowly defined measure M1 in the early sample period, 1961Q1-1979Q3, this ordering is reversed in the later sample period, 1979Q4-1986Q4. Second, while the variability of M1 growth increased most over the 1979Q4 to 1986Q4 period, that of M2 growth showed only a modest rise, and that of M3 fell.

[8] Carmichael and Stebbing (1983) and Fried and Howitt (1983).

[9] Several analysts including Carmichael and Stebbing (1983) and Fried and Howitt (1983) have emphasized that money and financial assets are likely to be highly substitutable at the margin. This is so because, apart from the medium of exchange function, money and financial assets are almost identical; they are both nominal stores of value, they have very similar liquidity and risk characteristics, and so on.

[10] The maximum rate payable on NOWs was initially set at 5¼ percent. As of January 1986 this restriction has been removed. The maximum rates payable on passbook savings accounts and several time deposits have also been completely deregulated. However, the explicit nominal rate payable on demand deposits held by businesses is still fixed at zero.

II.
Empirical Evidence

In this section I present empirical evidence on the relative roles of money growth volatility and financial deregulation in explaining the recent behavior of the nominal interest rate.

Specification of the Testable Hypothesis

The major thrust of the money growth volatility hypothesis is that the degree of monetary instability is an important determinant of nominal interest rates. A policy-induced increase in monetary instability tends to raise the level of the nominal interest rate, because such an increase raises uncertainty which, in turn, raises money demand. A simple way to test these implications is to estimate the following interest rate and money demand regressions:

$$i_t = a_0 + a_1\Pi_t - a_2MG_t + a_3X_t + a_4VOL_t \quad (1)$$

$$(M_t/P_t) = b_0 + b_1y_t - b_2R_t + b_3(M_{t-1}/P_t) + b_4VOL_t. \quad (2)$$

Equation (1) is the Fisher type interest rate regression in which i is the nominal interest rate, Π is expected inflation, MG is money growth, X is the variable measuring shift in exogenous aggregate demand, and VOL is the variable that measures the degree of monetary instability. Equation (2) is the standard money demand regression that includes real income (y), the short-term nominal interest rate (R_t), lagged real money balances (M_{t-1}/P_t), and money growth volatility (VOL) as the explanatory variables. The money growth volatility hypothesis posits that coefficients a_4 and b_4 attached to the VOL measure in regressions (1) and (2) are positive and significantly different from zero.

The alternative hypothesis is that financial deregulation is at the source of the strength in M1 demand. Furthermore, as a result of financial deregulation, the magnitude of the response of the nominal interest rate to expected inflation should have increased over the 1980s. In order to control for these effects of financial deregulation, consider the following expanded interest rate and money demand regressions

$$i_t = a_0 + a_1\Pi_t - a_2MG_t + a_3X_t + a_4VOL_t + a_5D81 \cdot \Pi_t \quad (3)$$

$$(M_t/P_t) = b_0 + b_1y_t - b_2R_t + b_3(M_{t-1}/P_t) + b_4VOL_t + b_5SHIFT_t \quad (4)$$

where all variables except D81 and SHIFT are as defined before. D81 is the zero-one dummy variable that takes values unity in the post-1981 period and zero otherwise. $D81 \cdot \Pi$ is formed by taking the product of D81 and expected inflation Π. SHIFT is a variable that captures the effect of financial deregulation on money demand. In empirical work this effect is captured by broadening the measure used in defining money. If the money growth volatility hypothesis is valid, then coefficients a_4 and b_4 should continue to be significant in (3) and (4).

It should, however, be pointed out that the aforementioned interest rate and money demand regressions (3) and (4) provide a test of the joint hypothesis that money growth volatility affects the nominal interest rate through the money demand channel. But money growth volatility could affect the nominal interest rate through other channels as well. In particular, increased money growth volatility also generates inflation uncertainty, which could directly change the real rate by influencing saving, investment, and real output. In general, the impact of inflation uncertainty on the equilibrium real rate is indeterminate. But, as shown in Makin (1983), inflation uncertainty could directly raise the real rate if it depresses saving more than investment.[11] With respect to the empirical tests proposed above, this point implies that the money growth volatility variable could be significant in the nominal interest rate regression (3) but not necessarily so in the money demand regression (4). Hence one must be careful in interpreting results from the tests conducted in this article.

Empirical Results

This section presents estimates of the interest rate and money demand regressions (3) and (4). All regressions are estimated over the common sample period, 1963-86. The interest rate regression[12] is estimated by the instrumental variable estimation

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[11] This impact may be enhanced if higher inflation uncertainty also depresses real output.

[12] Since the measure of expected inflation used in the interest rate regressions is based on the Livingston Survey inflation forecasts, the regressions are estimated using semiannual observations that correspond to the survey data collected each June and December. The variables included in the regressions are measured as follows: i is the average market yield on a one-year Treasury bill (June and December observations), Π is the Livingston Survey forecast of inflation over the 14-month horizon, and MG is the annualized growth rate of the nominal money stock over the last six months minus its annualized growth rate over the last three years (second- and fourth-quarter observations are used). The interest rate regression estimated here is in essence similar to the ones given in Carlson (1979), Peek (1982), Wilcox (1983), and Mehra (1985).

procedure, correcting estimated standard errors for the presence of any heteroscedastic disturbance term.[13] The money demand regression is estimated by the Hatanaka two-step estimation procedure that corrects for the presence of first order serial correlation.[14,15] The interest rate regressions are presented first, followed by money demand regressions.

Evidence from the Interest Rate Equation. Table III reports interest rate regressions that include money growth volatility and inflation interaction dummy variables. Regressions 3.1 and 3.2 indicate that the volatility variable based on the M1 measure of money is highly significant in explaining the nominal interest rate. The M1 volatility variable continues to appear statistically significant in the interest rate regressions that also included the inflation interaction dummy variable (see equation 3.2 in Table III).

Contrariwise, volatility variables based on broad measures of money do not do as well in these interest rate regressions (see equations 3.3, 3.4, 3.5, and 3.6 in Table III). In these the coefficient on the volatility variable remains positive but generally not statistically significant. Instead, the inflation interaction dummy variable usually appears significant in these regressions.

Nominal interest rate regressions that included volatility variables were also estimated over the 1963 to 1979 period. None of these volatility variables were significant however (these regressions are not reported).

At best, these estimates provide only a mixed support for the money growth volatility hypothesis. True, it appears that the heightened volatility of M1 growth is highly correlated with the nominal interest rate in the 1963 to 1986 period. But this correlation does not appear to indicate the presence of a systematic relation between the two variables. Money growth volatility variables are never significant in interest rate regressions estimated over the period excluding the 1980s. Furthermore, even over the sample period 1963-86 volatility variables based on broad measures of money are generally not significant in explaining the behavior of the nominal interest rate.[16,17]

The evidence from the money demand regression reviewed below further casts doubt on the validity of the money growth volatility hypothesis.

Evidence from the Money Demand Equation. An important assumption implicit in the volatility hypothesis is that an increase in monetary instability raises the demand for money. The money demand regressions reported in Table IV provide a direct test of this contention. Equation 4.1 (Table IV) is the standard money demand regression that includes the M1 volatility measure estimated over the period 1963-86. The coefficient on the volatility variable is of the hypothesized sign and statistically significant. This regression indicates that the degree of monetary instability is an important determinant of money demand.

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[13] Estimation treats MG endogenous with the instruments used including the contemporaneous and lagged values of the expected inflation rate, volatility, and inflation-interaction dummy variables and the lagged values of the nominal interest rate and money growth. The standard errors of the regression estimates were corrected for the presence of heteroscedasticity, using estimated covariance matrix as outlined in White (1980). Actual estimation was carried out by using the procedure outlined in *RATS*, Chapter 18, Section 3. It should be pointed out that the interest rate regressions reported in Table III of the text were also estimated by using ordinary least squares. Except for the coefficient on the variable MG, ordinary least squares estimates of other parameters are not different from the ones generated by the instrumental variable estimation procedure. Hence, the inference regarding the impact of volatility on the nominal interest rate is not sensitive to the estimation procedure chosen here.

[14] The money demand regressions are estimated using quarterly observations. The measures of nominal money used are M1, M2, and M3. The scale variable used is real GNP, and the opportunity cost of holding money is measured by the commercial paper rate (R). The degree of monetary instability is measured by the eight-quarter moving average standard deviation of the quarterly growth rates of actual money stock.

[15] The use of the lagged dependent variable in the money demand regression is subject to several well-known criticisms, as reviewed recently in Mehra (1986). Since this is the specification originally reported in Mascaro and Meltzer (1983) I chose the same, so that results could be compared. In view of the presence of a lagged dependent variable as well as serially correlated errors in the money demand regressions, the Hatanaka two-step estimation procedure, rather than the commonly employed Cochrane-Orcutt procedure, is used. The use of the Cochrane-Orcutt procedure can result in biased estimates of the parameters (Hatanaka (1974)). Nevertheless, the money demand regressions were also estimated by ordinary least squares, correcting standard errors for the presence of first-order serial correlation in the residuals. These estimates imply results similar to the ones based on the Hatanaka procedure.

[16] Kantor and O'Brien (1985) report a similar conclusion.

[17] As noted in the text, the interest rate regressions reported here included, in addition to volatility measures, other variables intended to capture the effects on the interest rate which are due to changes in expected inflation and monetary accelerations. Rises in expected inflation (Π) are found to raise interest rates while accelerations in money growth (MG) lower them (see Table III). Other variables such as supply shocks, lagged real income growth and changes in the exogenous components of aggregate demand were also tried and found generally insignificant in these interest rate regressions. In particular, I found no significant effect of the fiscal deficit on the level of the nominal interest rate. The interest rate regressions similar to those reported in Table III were reestimated including, in addition, the fiscal deficit variable (measured by the ratio of federal deficits to GNP). The coefficient that appears on this fiscal deficit variable is negative and generally insignificant.

Table III

Estimates of the Interest Rate Equation
Semiannual Data, 1963.06-1986.12

Independent Variables	Dependent Variable: One-Year Treasury Bill Rate					
	Eq. 3.1	Eq. 3.2	Eq. 3.3	Eq. 3.4	Eq. 3.5	Eq. 3.6
constant	1.0 (2.6)	1.4 (3.1)	2.0 (3.0)	2.5 (3.7)	2.5 (3.7)	2.1 (3.1)
Π	.8 (10.7)	.8 (10.8)	.9 (8.5)	.8 (7.6)	1.0 (9.7)	.8 (7.6)
MG	−38.7 (3.9)	−33.0 (3.2)	−33.8 (2.6)	−24.0 (1.8)	−31.2 (2.0)	−32.2 (2.1)
VOL($\dot{M}1$)	1.3 (9.8)	1.0 (4.6)				
VOL($\dot{M}2$)			.4 (1.8)	.1 (.5)		
VOL($\dot{M}3$)					.1 (.6)	.3 (1.3)
D81*Π		.2 (1.7)		.5 (5.2)		.6 (5.5)
CC	−8.2 (6.6)	−7.1 (5.1)	−.8 (5.5)	−3.6 (4.2)	−6.1 (5.9)	−4.6 (4.7)
$\bar{R}^2$	.82	.84	.59	.80	.58	.78
SER	1.24	1.18	1.87	1.13	1.89	1.37
DW	1.62	1.70	.59	1.51	.61	1.50

Notes: The nominal interest rate equation is estimated by instrumental variable procedure, and t values (absolute values reported in parentheses) have been corrected for the presence of heteroscedacity (see footnote 13). Π is the expected inflation proxy (measured here by the Livingston Survey forecast of inflation), MG is the annualized growth rate of the nominal money stock (M1 or M2 or M3) over the last six months minus its annualized growth rate over the last three years, and VOL ($\dot{M}$) is the moving-average standard deviation of quarterly changes in the money stock. VOL($\dot{M}1$) is based on M1 measure of money; VOL($\dot{M}2$), on M2; and VOL($\dot{M}3$), on M3. D81*Π is formed by taking the product of Π and a dummy variable that takes values 1 in 1981-86 and zero otherwise. CC is the credit control dummy taking value unity in 1980.06 and zero otherwise. Estimation treats the variable MG endogenous, and the instruments used included the contemporaneous and lagged values of the expected inflation rate, volatility, and inflation-interaction dummy variables and the lagged values of the nominal interest rate and money growth.

But this conclusion is quite fragile. The regression 4.1 (Table IV) is the standard money demand regression estimated in level form and including a lagged dependent variable. When this regression is estimated either in the first difference form or with simple distributed lags, the volatility variable (VOL($\dot{M}1$)) becomes insignificant. Likewise, that variable is no longer significant in the money demand regression estimated over the early sample period, 1963-79 (these regressions are not reported).

The money demand regression 4.1 (Table IV) does not allow for evaluation of the alternative hypothesis that M1 demand during the 1980s was affected by the inclusion in M1 of interest-bearing NOWs and Super NOWs. In particular, as explained before, broad measures of money, since they internalize deregulation-induced substitutions from components of M1 to components of M2 and M3, provide a more stringent test of the money demand channel of the volatility hypothesis. Hence the regression 4.1 (Table IV) is reestimated using instead the M2 and M3 measures of money as the left-hand-side dependent variable. The result (see equations 4.2 and 4.3 in Table IV) is that M1 volatility variable is no longer statistically significant.[18] On balance, these results do not support the contention that money growth volatility is a significant determinant of the public's demand for real money balances.[19]

[18] It should also be pointed out that money growth volatility variables based on broad measures of money are not statistically significant in such regressions.

[19] Hall and Noble (1987) use Granger-causality tests to show that volatility influences velocity. However, this causality result is also shown not to be very robust (Mehra (1987)).

Table IV

Estimates of the Money Demand Equation
Quarterly Data, 1963Q1-1986Q4

Independent Variables	Dependent Variable: Equation 4.1 M1		Equation 4.2 M2		Equation 4.3 M3	
constant	−.38	(4.2)	−1.01	(4.4)	−.81	(2.7)
y_t	.05	(3.4)	.19	(4.6)	.14	(2.9)
R_t	−.02	(4.9)	−.03	(7.1)	−.01	(3.0)
M_{t-1}/P_t	.99	(36.8)	.84	(22.5)	.90	(25.2)
$VOL(\dot{M}1)$	.002	(2.1)	.001	(1.5)	−.000	(.1)
D74	−.002	(1.4)	.001	(1.1)	.000	(.2)
D742	.0001	(1.2)	−.000	(1.1)	.000	(.1)
$\bar{R}^2$	.99		.99		.99	
SER	.00615		.00487		.00477	
DW	2.0		2.2		1.70	
Rho	.11	(1.2)	.43	(5.1)	.75	(10.3)

Notes: The money demand regression estimated by the Hatanaka procedure is of the following form:

$$\ln (M_t/P_t) = b_0 + b_1 \ln y_t - b_2 \ln R_t + b_3 \ln(M_{t-1}/P_t) + b_4 VOL(\dot{M}1)$$

where y is real GNP, R is the commercial paper rate, P is the implicit GNP deflator, and $VOL(\dot{M}1)$ is the measure of M1 volatility. D74 is the dummy variable that takes value 0 through 1974Q1, 1 in 1974Q1, incrementing by ones until it reaches 11 in 1976Q4 and remaining at 11 thereafter. D742 is the square of D74. ln is the natural logarithm. Parentheses contain absolute values of t statistics. The regression is estimated using M1, M2, and M3 as the dependent variable, but the VOL variable used is based on M1.

III. Concluding Remarks

If one focuses primarily on the behavior of M1—the narrowly defined measure of money—then the evidence reviewed here supports the contention that the volatility of money growth did increase during the period that followed the change in monetary control procedures. Since then M1 demand has also been stronger than predicted from its past relationship with real income, the price level, and the nominal interest rate. Furthermore, some specifications of interest rate and money demand equations suggest that the increased volatility of money stock raised money demand and thus contributed to high levels of nominal interest rates in the 1979-86 period.

An entirely different set of inferences emerges if one focuses on the behavior of broad monetary aggregates. The error in predicting money demand over this period is sharply lower when a broad definition of money is used in the money demand regression, suggesting that M1 demand had in fact been affected by changing asset preferences of the public. If one controls for this effect and uses the broad definition of money in measuring volatility, then the evidence reported here does not support the hypothesized causal link between the degree of monetary instability and the level of the nominal interest rate. Money stock volatility does not exert an independent influence on the public's demand for real money balances.

An increase in the demand for money not caused by increased money stock volatility could have contributed to high nominal interest rates in the 1979 to 1986 period. Also the nominal interest rate now moves more in line with expected inflation than before. This consideration too could explain part of the high levels of interest rates observed in recent years.

What do the results presented imply for monetary policy? An important issue raised by changes in Federal Reserve operating procedure is whether money stock volatility matters enough to receive an independent weight in policy decisions. Some analysts contend it does matter enough, because it induces interest rate volatility and generates uncertainty about monetary policy. This uncertainty then supposedly raises the general level of interest rates, with adverse consequences for the performance of the economy.[20] If so, the Federal Reserve should pay serious attention to the volatility of the growth path of the money stock, in addition to focusing on money's growth rate.

[20] Evans (1984) and Tatom (1985).

The empirical work reported in this article, however, provides mixed support for the above view. A policy-induced rise in the volatility of money growth is likely to be associated with a rise in the volatility of the interest rate since accelerations or decelerations in the growth rate of the money stock influence nominal interest rates in the short run. This result is due to the so-called liquidity effect of money on interest. However, the evidence presented to support the hypothesis that money stock volatility exerts an independent influence on the level of the nominal interest rate is not robust. Thus it is not clear that money stock volatility ought to be given an independent weight in monetary policy decisions.

References

Carlson, John A. "Expected Inflation and Interest Rates." *Economic Inquiry* 17 (October 1979): 597-608.

Carmichael, J., and P.W. Stebbing. "Fisher's Paradox and the Theory of Interest." *The American Economic Review* 73 (September 1983): 619-31.

Clarida, Richard H., and Benjamin M. Friedman. "The Behavior of U.S. Short-Term Interest Rates Since October, 1979." *The Journal of Finance* 39 (July 1984): 671-82.

Evans, Paul. "The Effects on Output of Money Growth and Interest Rate Volatility in the United States." *Journal of Political Economy* 92 (April 1984): 204-22.

Fried, J., and P. Howitt. "The Effects of Inflation on Real Interest Rates." *The American Economic Review* 73 (December 1983): 968-80.

Hall, Thomas E., and Nicholas R. Noble. "Velocity and the Variability of Money Growth: Evidence from Granger-Causality Tests." *Journal of Money, Credit, and Banking* 19 (February 1987): 112-16.

Hatanaka, Michio. "An Efficient Two-Step Estimator for the Dynamic Adjustment Model with Autoregressive Errors." *Journal of Econometrics* 2 (September 1974): 199-220.

Hetzel, Robert L., and Yash Mehra. "The Behavior of Money Demand in the 1980s." Federal Reserve Bank of Richmond, October 1987. Photocopy.

Kantor, Laurence G., and Paul F. O'Brien. "Money Volatility and Interest Rate Volatility." Board of Governors, Federal Reserve System, 1985. Photocopy.

Kretzmer, Peter B., and Richard D. Porter. "The Demand for the Narrow Aggregate—Is a Transaction Approach Sufficient?" Board of Governors of the Federal Reserve System, 1986. Photocopy.

Makin, John H. "Real Interest, Money Surprises, Anticipated Inflation and Fiscal Deficits." *The Review of Economics and Statistics* 65 (August 1983): 374-84.

Mascaro, Angelo, and Alan H. Meltzer. "Long- and Short-term Interest Rates in a Risky World." *Journal of Monetary Economics* 12 (November 1983): 485-518.

Mehra, Yash. "Inflationary Expectations, Money Growth, and the Vanishing Liquidity Effect of Money on Interest: A Further Investigation." Federal Reserve Bank of Richmond, *Economic Review* 71 (March/April 1985): 23-35.

————. "Recent Financial Deregulation and the Interest Elasticity of M1 Demand." Federal Reserve Bank of Richmond, *Economic Review* 72 (July/August 1986): 13-24.

————. "Velocity and the Variability of Money Growth: Evidence from Granger-Causality Tests Reevaluated." Working Paper 87-2. Federal Reserve Bank of Richmond, August 1987.

Peek, Joe. "Interest Rates, Income Taxes, and Anticipated Inflation." *The American Economic Review* 72 (December 1982): 980-91.

Simpson, Thomas D. "Changes in the Financial System: Implications for Monetary Policy." *Brookings Paper on Economic Activity* (1:1984), pp. 249-65.

Spindt, Paul A., and Vefa Tarhan. "The Federal Reserve's New Operating Procedures: A Post Mortem." *Journal of Monetary Economics* 19 (January 1987): 107-23.

Tanzi, Vito. "Inflationary Expectations, Economic Activity, Taxes, and Interest Rates." *The American Economic Review* 70 (March 1980): 12-21.

Tatom, John A. "Interest Rate Variability and Economic Performance: Further Evidence." *Journal of Political Economy* 93 (October 1985): 1008-18.

Trehan, Bharat, and Carl Walsh. "Portfolio Substitution and Recent M1 Behavior." *Contemporary Policy Issues* 5 (January 1987): 54-63.

Wenninger, John. "Responsiveness of Interest Rate Spreads and Deposit Flows to Changes in Market Rates." Federal Reserve Bank of New York, *Quarterly Review* 11 (Autumn 1986): 1-10.

White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and Direct Test for Heteroskedasticity." *Econometrica* 48 (May 1980): 817-38.

Wilcox, James A. "Why Real Interest Rates Were so Low in the 1970's." *The American Economic Review* 73 (March 1983): 44-53.