Weekly Money Supply Announcements and the Volatility of Short-Term Interest Rates

By V. Vance Roley

On October 6, 1979, the Federal Reserve announced a change in its monetary control procedures. Before that time, the Federal Reserve focused on controlling short-term interest rates in an effort to achieve the System's monetary growth objectives. Under the new procedures, the Federal Reserve attempts to achieve its monetary growth objectives by focusing on the availability of reserves to financial institutions.[1] Also under the new procedures, short-term interest rates are allowed to vary over a wider range than they were prior to October 1979. For this reason, it is not surprising to find that interest rates have fluctuated more since October 1979 than previously. However, a variety of other factors—such as an acceleration of financial innovation and regulatory change as well as sharp fluctuations in both financial and nonfinancial sectors of the economy—also may have contributed to the increased volatility.

A useful way to identify the role of the change in procedures on interest rate volatility is to focus on the increase that has occurred since October 1979 in fluctuations in interest rates that follow weekly announcements of changes in the money supply. These announcements, which are made each Friday by the Federal Reserve, provide new information about money supply developments that participants in financial markets use to adjust their assessments of the current availability of reserves as well as the future course of monetary policy.[2] For example, the announcement of a larger-than-anticipated change in the money supply may lead market participants to expect a change in the Federal Reserve's monetary policy that will affect interest rates. In anticipating the change in policy, market participants may then take actions that lead to immediate movements in interest rates. The October 1979 change in operating procedures may have affected the magnitude of interest

V. Vance Roley is an assistant vice president and economist with the Federal Reserve Bank of Kansas City. Research assistance was provided by Rick Troll, a research associate with the Bank.

[1] For descriptions of the operating procedures adopted by the Federal Reserve on October 6, 1979, and comparisons to the previous approach, see J. A. Cacy, "Monetary Policy in 1980 and 1981," *Economic Review,* Federal Reserve Bank of Kansas City, December 1980, pp. 18-25; and Board of Governors of the Federal Reserve System, "Monetary Policy Objectives for 1981," February 1981.

[2] In the first section of this article, the role of the Federal Reserve in influencing the response of interest rates to weekly money supply announcements is further discussed. This discussion indicates that there are two basic links. One involves an unchanged nonborrowed reserve path, and the other incorporates a change in the path in an attempt to offset deviations in money growth. The latter is referred to here as a change in policy.

rate volatility associated with the money supply announcements.

The purpose of this article is to examine the fluctuations in interest rates associated with weekly money supply announcements in order to determine the role of the change in the Federal Reserve's operating procedures on interest rate volatility. The first section discusses alternative theories of the possible effects of money supply announcements on interest rates. The volatility of announced changes in the money supply and the associated interest rate volatility before and after October 1979 are described in the second section. The third and fourth sections empirically examine the relationship between announced changes in money and interest rate volatility to determine if the market's response to the announcements has been altered by the October 1979 change in operating procedures. The main conclusions of the article are summarized in the final section.

MONEY ANNOUNCEMENTS AND INTEREST RATES: THEORETICAL CONSIDERATIONS

This section discusses alternative theories about the relationship between interest rate movements and money supply announcements. The discussion focuses first on the simple textbook model, which implies a negative relationship between changes in money and interest rates. Then, two alternative explanations of a positive relationship between money and interest rates are presented. The latter of these two—which is based on the market's assessment of Federal Reserve policy—appears to best represent the observed responsiveness of interest rates to money supply announcements.[3]

Liquidity Effect

In the simple classroom model, there is a negative relationship between changes in money and interest rates, as an increase in the supply of money implies that interest rates should fall, and a decrease in money implies that rates should rise. This notion is based on the theory of liquidity preference, which models an individual's desire to hold liquid assets—usually taken to consist entirely of money.[4] In this model, an increase in the supply of money causes the amount supplied to exceed the amount demanded. Thus, individuals attempt to reallocate their portfolios toward assets with market-determined yields. However, with a fixed supply of these assets, demand is now greater than supply, which causes the price of these assets to rise, or interest rates to fall, in order to clear the market. As a result of the drop in interest rates on these alternative assets, individuals are willing to hold a larger amount of money.

The liquidity effect, then, implies that money and interest rates are negatively related. In contrast, financial market observers note frequently that large announced weekly increases in money, for example, are associated with rises in short-term interest rates. Is this observation inconsistent with the liquidity effect? Despite claims to the contrary, the answer to this question is no. The reason is that the liquidity effect is not relevant in the analysis of weekly money announcements. In particular, the weekly changes in money announced each Friday at 4:10 p.m., e.s.t., correspond to the change in the level of money during the statement week ending on Wednesday of the previous week.

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[3] For a further discussion of several of the effects discussed below, see William E. Gibson, "Interest Rates and Monetary Policy," *Journal of Political Economy,* May-June 1970, pp. 431-55.

[4] For early descriptions of this theory, see John Maynard Keynes, *The General Theory of Employment, Interest and Money,* Harcourt, Brace & World, 1936; and John R. Hicks, "Mr. Keynes and the Classics: A Suggested Interpretation," *Econometrica,* April 1937, pp. 147-59.

Thus, any Federal Reserve policy action involving an increase in reserves to stimulate money growth, for example, affects money market rates during the statement week in which this action occurs, not the subsequent week when the money announcement is made. Thus, a liquidity effect is not observed at the time of the weekly money supply announcement.

Inflation Effect

Some observers have relied on the well-known positive relationship between money growth and inflation to explain the movements of interest rates at the time of a money announcement. In the long run, most would agree that a Federal Reserve policy of trying to stimulate money growth leads to an increase in inflation. This rise in inflation then causes interest rates to rise in order to maintain real interest rates—nominal rates minus inflation—at their equilibrium levels.[5] Thus, in the long run, an increase in money growth which stimulates inflation causes nominal rates to rise.

In applying the inflation effect to movements in interest rates immediately following a money announcement, two factors should be noted. First, the notion that financial markets are efficient implies that investors use all available information in determining their demands for securities. In turn, because market yields already reflect expectations of the future announced changes in money, only unanticipated changes in money affect interest rates immediately following a money announcement. Second, the movement of long-term interest rates at the time of a money announcement may, in part, be explained by the inflation effect. In particular, if the market interprets a larger-than-expected increase in the weekly money announcement as a development that will be continued, or at least not offset, they may expect higher inflation and hence higher interest rates in the long run.

The inflation effect, however, probably accounts for very little of the movement in short-term yields associated with unanticipated weekly changes in money. It may not be reasonable to assume that the market interprets a larger-than-expected increase in the weekly money announcement as implying that inflation will thereby increase in the very short run. Yet, such changes in money do typically cause very short-term yields to move significantly in the same direction. Thus, some other reason must account for these movements.

Policy Expectations Effect

To explain the positive relationship between short-term interest rates and unanticipated weekly changes in money, several economists have advanced the notion that this behavior merely reflects the market's expectation of future Federal Reserve actions.[6] In this theory, market participants are again assumed to use all available information—including the anticipated announced change in money—in determining their demands for money and other assets before the announcement. If the announcement is higher than anticipated, for example, market participants may then expect higher short-term interest rates if they expect that the Federal Reserve will try to offset this increase by reducing the growth of bank

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[5] For further details of this theory, see, for example, Milton Friedman, "The Role of Monetary Policy," *American Economic Review,* March 1968, pp. 1-17.

[6] See, for example, Thomas Urich and Paul Wachtel, "Market Response to the Weekly Money Supply Announcement in the 1970s," *Journal of Finance,* December 1981, pp. 1063-72; and Jacob Grossman, "The Rationality of Money Supply Expectations and the Short-Run Response of Interest Rates to Monetary Surprises," *Journal of Money, Credit, and Banking,* November 1981, pp. 409-24.

reserves. Investors will then act to cause interest rates to increase immediately.

Even if market participants do not expect a reduction in the growth of bank reserves in response to an unanticipated increase in the money supply, short-term interest rates may nevertheless rise under a reserve-aggregate approach to monetary control. In particular, because of the lagged reserve accounting framework used by the Federal Reserve in imposing reserve requirements, the current demand for reserves depends on deposits in the statement week ending on Wednesday of the previous week. Thus, a higher-than-expected announced change in the money supply may cause investors to increase their assessment of the aggregate demand for reserves. In turn, if investors expect the supply of reserves to remain unchanged throughout the remainder of the current statement week, then short-term interest rates will be expected to rise to equilibrate supply and demand in the reserve market.

Effects of the October 1979 Change in Operating Procedures

Through the policy expectations effect, the Federal Reserve's change in its monetary control procedure may have heightened the responsiveness of short-term interest rates to unanticipated weekly changes in money. In particular, if investors believe that the new operating procedures are part of a program to achieve closer short-run control of the monetary aggregates, it may be rational for short-term yields to be more responsive to unanticipated changes in money than previously. Furthermore, under the pre-October 1979 operating procedures, any excess demand for reserves would have been at least partially accommodated to maintain stable money market interest rates. In contrast, under the new procedures, any excess demand for reserves resulting from an unanticipated weekly change in money is not accommodated, implying that money market interest rates must move to equilibrate the market.

THE VOLATILITY OF WEEKLY MONEY SUPPLY ANNOUNCEMENTS AND SHORT-TERM INTEREST RATES SINCE 1977

In this section, an examination is made of the performances of weekly M1 announcements and short-term interest rates over the last four years. The focus is on M1 because of the emphasis placed on M1 by Federal Reserve policymakers and market participants. Following the discussion of the observed money announcements, expected M1 announcements taken from a market survey are used to construct a series representing the market's forecast error, or surprise, associated with each money announcement. As discussed in the previous section, this surprise plays a crucial role in estimating the market's response to a given money announcement.

Volatility of Weekly Money Supply Announcements

This section compares the volatility of announced weekly changes in M1 in three periods. The first period begins on September 29, 1977—the date when the survey discussed below was initiated—and ends on October 4, 1979—the last announcement date before the Federal Reserve's switch to the reserve-aggregate monetary-control procedure. Throughout this period, the reported money figures correspond to "old M1." The second period begins on October 11, 1979—the first announcement after the Federal Reserve's policy implementation change—and ends on January 31, 1980—the last time that weekly money changes were reported on Thursday. Throughout this period, money announcements

Table 1
SUMMARY STATISTICS FOR MONEY AND INTEREST RATES SINCE 1977

Period:*	Mean			Standard Deviation		
	I	II	III	I	II	III
Announced M1 changes†	0.297	0.276	0.403	2.081	1.594	2.796
				Root-Mean-Square Error		
				I	II	III
Unanticipated M1 changes‡	−0.397	0.235	0.068	1.584	1.270	2.334
Changes in 3-month Treasury bill yield§	−0.007	0.013	0.003	0.040	0.101	0.250

*Period I starts on September 29, 1977, and ends on October 4, 1979; Period II starts on October 11, 1979, and ends on January 31, 1980; Period III starts on February 8, 1980, and ends on November 20, 1981.

†Announced weekly change in the narrowly defined money stock, in billions of dollars. (Source: Board of Governors of the Federal Reserve System, H.6.)

‡Difference between the announced money change and the anticipated money change, where the anticipated change is the median of a market survey. (Source: Money Market Services, Inc.)

§Change in the average of the bid and ask quotations on the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of the money announcement, in percentage points. (Sources: Federal Reserve Bank of New York, "Quote Sheet of Closing Rates," and Telerate data base.)

also correspond to old M1. The final period begins on February 8, 1980—the first date that weekly money changes were announced on Friday—and ends on November 20, 1981. Not only were money announcements made on Friday during this period, but the announcements were in terms of the new definition of money, M1-B.[7]

Table 1 shows summary statistics for the volatility of money and interest rates for the three periods described above. In the first row of the table, the mean and a measure of volatility—the standard deviation—are reported for announced M1 changes.[8] Although the average money announcement remained close to $0.3 billion for each of the three periods, the standard deviation increased markedly from the first to the third periods. In the first period, the standard deviation was around $2.1 billion—implying that about 95 percent of the time money announcements could be expected to be within −$4.2 billion to +$4.2 billion of the mean of $0.3 billion. In contrast, in the third period, the standard

[7] M1-B is now simply M1. Old M1 differs from the current definition mainly in that it excluded "other checkable deposits" at depository institutions. It should also be noted that the M1-B data for 1981 are those for nonshift-adjusted money balances. Starting in 1981, M1-B was adjusted by the Federal Reserve to reflect the introduction of nationwide NOW accounts. While the target range for shift-adjusted M1-B was emphasized by the Federal Reserve, weekly announced changes in M1-B were not shift adjusted.

[8] The mean of a data series X_t (t = 1,...,N) is defined as

$$\text{Mean} = \bar{X} = (1/N) \cdot \sum_{t=1}^{N} X_t.$$

The standard deviation is defined as

$$\text{Standard Deviation} = \left\{ [(1/N-1)] \cdot \sum_{t=1}^{N} (X_t - \bar{X})^2 \right\}^{1/2}.$$

deviation was $2.8 billion, implying that the interval increased to −$5.6 billion to +$5.6 billion. Most of this increased volatility is due to several extraordinarily large announced changes in M1 in the third period.

Market Anticipations and Unanticipated Changes in the Money Supply

While announced weekly changes in the narrowly defined money supply have in fact exhibited more volatility recently, this does not necessarily imply that the associated changes in interest rates will also be more volatile. As discussed earlier, if the money market efficiently uses all available information in determining short-term interest rates, then rates should respond only to unanticipated changes in M1. In the second row of Table 1, the mean and the volatility of unanticipated changes in money are reported. An unanticipated change is defined to be equal to the announced change in money minus the change anticipated by market participants as indicated by a market survey.[9] As indicated in the table, the volatility of unanticipated changes in M1, as measured by the root-mean-square error—which is similar to the standard deviation statistic—was significantly greater in the third period than in the two previous periods.[10]

Volatility of Short-Term Interest Rates

To the extent that larger unanticipated money changes may be expected to cause larger swings in interest rates immediately following a money announcement, interest rates should exhibit more volatility in the third period than in the first period. Such a relationship is in fact borne out, as is apparent in Chart 1, where changes in the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of the money supply announcement are plotted from September 29, 1977, through November 20, 1981. Because changes in narrowly defined money are announced at 4:10 p.m., the movements in the Treasury bill yield illustrated in the chart may be attributed almost entirely to money announcements. These movements range from −12 to +14 basis points in the first period, and from −74 to +123 basis points in the post-October 1979 period.

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9 The survey data used here are those collected by Money Market Services, Inc., which surveys about 60 money market participants each week. Before February 8, 1980, surveys were conducted twice each week, on Tuesday and Thursday. Since then the survey has been conducted only once each week, on Tuesday. For the first subsample, the median of the Thursday survey is used to represent the market's anticipated money announcement on each Thursday. For the latter subsample, the median of the Tuesday survey is used for each Friday's money announcement. A correction was also considered for this period in an attempt to update the survey measure to reflect new information available from Tuesday—the day of the survey—to Friday, the day of the money announcement. This adjustment was attempted because in the first two periods, the survey is on the day of the announcement. To represent the receipt of new information, the change in the 3-month Treasury bill yield from Tuesday at 5:00 p.m. to Friday at 3:30 p.m. was used. In the linear model used in the empirical investigation, this revised expectation measure and the median of Tuesday's survey yielded qualitatively similar results. Thus, results using the revised expectations measure are not discussed further in the article. I am indebted to Mr. Raul A. Nicho, who is a vice president with Money Market Services, Inc., for making the survey data available for this project. For a description of the various methods used by market participants to form their weekly money forecasts, see Charles Sivesind, "Fed-watching and Market Reaction," mimeo, Federal Reserve Bank of New York, March 1978.

10 For unanticipated money changes, defined as $\Delta M_t - \Delta M_t^e$ $(t = 1,\ldots,N)$ where ΔM_t is the announced weekly change and ΔM_t^e is the median of the market survey, the mean and root-mean-square error are computed as

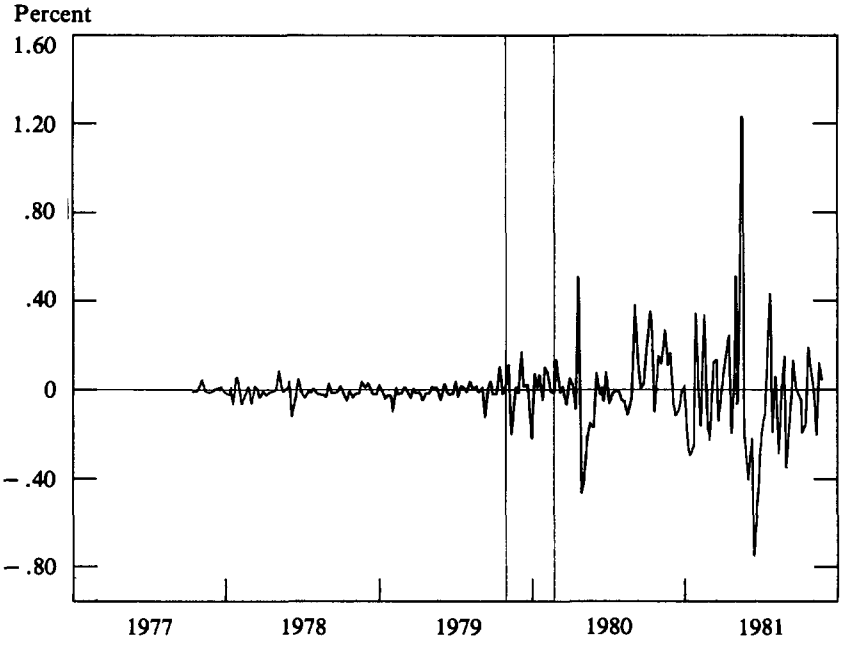
$$\text{Mean} = (1/N) \cdot \sum_{t=1}^{N} (\Delta M_t - \Delta M_t^e)$$

and

$$\text{Root-Mean-Square Error} = \left[(1/N) \cdot \sum_{t=1}^{N} (\Delta M_t - \Delta M_t^e)^2\right]^{1/2}.$$

The root-mean-square error is a measure of forecast accuracy, while the standard deviation statistic reported for announced changes in money is a measure of fluctuations around the average observed change over a given period.

Chart 1
CHANGES IN THE 3-MONTH TREASURY BILL YIELD
(3:30 p.m. to 5:00 p.m. on days of money announcements)



This increase in volatility is also evident in the last row of Table 1. In the first period, the root-mean-square error of the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of the money announcement was about 4 basis points.[11] In contrast, in the third period, this value rose substantially to 25 basis points.

THE IMPACT OF UNANTICIPATED CHANGES IN THE MONEY SUPPLY

In the previous section, summary statistics were provided indicating that both unanticipated weekly changes in narrowly defined money and associated changes in short-term interest rates have exhibited greater volatility since the Federal Reserve adopted a reserve-aggregate approach to monetary control on October 6, 1979. At this point, however, it is not possible to attribute all of the increase in interest rate volatility to the greater volatility of unanticipated money. As discussed above, the increase in interest rate volatility may be due in part to a rise in the magnitude of the market's response to a given money surprise, and the Oc-

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[11] For the change in the 3-month Treasury bill yield from 3:30 to 5:00 p.m., ΔR_t $(t = 1,\ldots,N)$, the statistics are computed as

$$\text{Mean} = (1/N)\cdot \sum_{t=1}^{N} \Delta R_t$$

and

$$\text{Root-Mean-Square Error} = \left[(1/N)\cdot \sum_{t=1}^{N} (\Delta R_t)^2\right]^{1/2}.$$

tober 1979 change in procedures may have caused such a greater response. In this section, the relationship between unanticipated changes in money and changes in short-term interest rates is empirically examined to determine whether the magnitude of the market's response has increased since October 1979. The model used in the empirical work is discussed next, followed by the presentation of the estimation results.

The Model

An efficient markets model is used to examine the relationship between unanticipated changes in money and interest rates. This model assumes that investors efficiently use all publicly available information in setting interest rates in the money market. Thus, the 3-month Treasury bill yield at 3:30 p.m. on the day of the announcement should reflect the market's expectation of the announced money change at 4:10 p.m.

The implications of the efficient markets model as applied here are twofold. First, the movement of the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of the money announcement should depend only on information obtained by investors between 3:30 and 5:00 p.m. Thus, at 3:30 p.m., the market's best forecast of the yield at 5:00 p.m. is the observed yield at 3:30 p.m.

Second, any relevant information obtained between 3:30 and 5:00 p.m. on the day of the money announcement should influence the 3-month yield during this period, but information already known by investors should not. Thus, the new information obtained from the money announcement may significantly affect the Treasury bill yield. Together, these considerations imply that the Treasury bill yield changes from 3:30 to 5:00 p.m. according to the following equation:

$$(1)\quad \Delta R_t = c \cdot (\Delta M_t - \Delta M_t^e) + u_t.$$

In the equation, ΔR is the change in the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of the money announcement, $\Delta M_t - \Delta M_t^e$ is the unanticipated change in the money supply, c reflects the estimated response of the 3-month Treasury bill yield to unanticipated changes in money, and u_t is a random error term. In brief, therefore, the model relates changes in the 3-month Treasury bill yield to unanticipated changes in the money supply.

Has the Market Altered Its Response to Unanticipated Changes in Money?

The model shown above can be used to determine whether the market has altered its response to unanticipated changes in money. If the response has increased, then part of the rise in interest rate volatility can be attributed to this source. The market's response to unanticipated changes in money is estimated for periods I and III in Table 2. Period II is not considered because it corresponds to a period of transition by market participants to the new operating procedures.[12]

The estimates in the table measure the change in the 3-month Treasury bill yield from 3:30 to 5:00 p.m. in response to unanticipated changes in money. In the third period, for example, a $1 billion surprise in announced money will on

[12] Market participants may learn the implications of the Federal Reserve's announced policy change on October 6, 1979, only after observing Federal Reserve behavior for several months. Thus, this period may not be an accurate guide to ultimate market behavior. This learning behavior is consistent with the rational expectations models presented by John B. Taylor, "Monetary Policy During a Transition to Rational Expectations," *Journal of Political Economy*, October 1975, pp. 1009-21; and Benjamin M. Friedman, "Optimal Expectations and the Extreme Information Assumptions of 'Rational Expectations' Macromodels," *Journal of Monetary Economics*, January 1979, pp. 23-41.

Table 2
CHANGES IN THE MARKET'S RESPONSE TO UNANTICIPATED MONEY

$$\Delta R_t = c \cdot (\Delta M - \Delta M_t^e) + u_t$$

Estimation Period	Estimated Coefficients*	Summary Statistics		
	c_1	$\bar{R}^2$	SE	DW
9/29/77-10/4/79	0.0078 (0.0024)	0.07	0.040	1.87
2/8/80-11/20/81	0.0587 (0.0093)	0.30	0.209	1.95

*Numbers in parentheses are standard errors of estimated coefficients.

$\Delta R_t = R_{5:00,t} - R_{3:30,t}$

ΔM_t = announced weekly change in narrowly defined money in week t, in billions of dollars

ΔM_t^e = survey median of announced weekly change in narowly defined money in week t, in billions of dollars

c = estimated coefficient

u_t = random error term uncorrelated with any information available in the previous week (week t-1)

$\bar{R}^2$ = multiple correlation coefficient corrected for degrees of freedom

SE = standard error

DW = Durbin-Watson statistic

average cause the Treasury bill yield to increase by 0.059 percentage points, or 5.9 basis points. In contrast, in the first period, a similar surprise results in only a 0.8 basis point increase. Thus, the market has become much more responsive to unanticipated changes in money since October 1979.[13] The estimation results, therefore, indicate that one source of increased interest rate volatility is the greater responsiveness of the market to such unanticipated changes. In turn, the greater responsiveness may represent rational behavior by investors toward the new operating procedures.

UNANTICIPATED MONEY SUPPLY CHANGES AND FEDERAL RESERVE POLICY TARGETS

This section undertakes a further empirical examination of the relationship between unanticipated changes in money and interest rates. The purpose is to determine the factors that influence the size of the response and to identify the sources of the post-October 1979 rise in interest rate volatility.

With regard to the factors that influence the size of the market's response, the analysis considers whether the response is different for positive and negative money surprises. Also considered is whether the response varies depending on the relation of the money supply to the Federal Reserve's long-run growth range. Both of these factors may cause different interest rate responses to a money surprise of a given size if market participants believe that the Federal Reserve adjusts its short-run monetary policy asymmetrically. In particular, as part of a greater commitment to reduce inflation, market participants may expect the Federal Reserve to significantly tighten policy in response to large announced increases in money. Moreover, if money growth is currently above the upper limit of the long-run range, investors may expect the Federal Reserve to take even swifter and more significant actions. If money records a large decline, however, market participants may expect only a limited response by the Federal Reserve. Thus, the interest rate response to unanticipated changes in money may depend on both the relation of current

[13] The hypothesis that the market's response is equal in the first and third periods can be rejected at the 1 percent level of significance. To avoid potential problems associated with heteroscedasticity, each of the estimated equations in the test was weighted by the reciprocal of its estimated standard error.

money growth to the long-run range and the sign of the money surprise.[14]

The Model

The model used in this investigation is as follows:

$$(2)\quad \Delta R_t = c_{11}\cdot UM^{+}_{a,t} + c_{12}\cdot UM^{-}_{a,t} + c_{13}\cdot UM^{+}_{w,t} + c_{14}\cdot UM^{-}_{w,t} + c_{15}\cdot UM^{+}_{b,t} + c_{16}\cdot UM^{-}_{b,t} + u_t.$$

In the model, the variable UM represents unanticipated changes in money—which is the same as $\Delta M - \Delta M^e$ in the previous model; the subscripts a, w, and b denote money growth above, within, and below the long-run ranges, respectively; the superscripts + and − denote positive and negative unanticipated change in money; and the c's are estimated coefficients measuring the market's response.[15] This model differs from model (1) in that unanticipated changes in money are disaggregated according to whether the unanticipated change is positive or negative, and whether observed money growth is above, within, or below the long-run ranges set by the Federal Reserve. If the estimates of the market's responses across these various classifications have equal value, then this model reduces to that of the previous section.

Monetary Policy Targets and the Market's Response

Through the use of the above model, the hypothesis that the market responds equally to all types of money surprises is tested. The results shown in the top portion of Table 3 indicate that this hypothesis can be rejected, although perhaps only marginally in the first period, since the "c" values differ across the various classifications.[16] Thus, it appears that the market does exhibit some tendency to respond differently to the individual classifications of money surprises considered here. This behavior is particularly evident in the estimation results for the third period. Specifically, in the case of money growth above the upper limit of the long-run range, a +$1 billion surprise causes on average a 14 basis point increase in the Treasury bill yield, and a −$1 billion surprise is associated with only a 5 basis point decline, as shown in the table by the values of c_{11} and c_{12}.[17]

The estimation results also indicate that the market's response to different categories of

14 The market's response to unanticipated changes in M1 may not only depend on the relation of M1 to its long-run range, but also the behavior of M2 with respect to its long-run range. The investigation of this possibility is, however, beyond the scope of this study.

15 The long-run ranges adopted by the Federal Reserve are used in the model (2). Prior to 1979, annual long-run ranges were set each quarter, and they spanned the current and next three quarters. From the third quarter of 1977 through the third quarter of 1978, the growth ranges were set each quarter at 4 to 6.5 percent for M1. Thus, despite the fact that the public was not informed about these ranges until at least one month after they were set, it is assumed that throughout this period the market accurately assessed the ranges because of their rather lethargic nature. In the fourth quarter of 1978, the Federal Reserve departed from its 4-6.5 percent range as a consequence of the introduction of the automatic transfer service (ATS). In this case, as with those that follow, it is again assumed that the market correctly assessed the long-run range for narrowly defined money before its public availability. Since 1979, the Federal Reserve has set a single long-run range for each monetary and credit aggregate, with the ranges spanning an entire calendar year. These ranges are announced each February, and the Federal Reserve has the opportunity to change them each July. Moreover, preliminary ranges for the subsequent year are announced in July. Thus, with this information, the market may be expected to form fairly accurate assessments of the long-run policy ranges.

16 Again, hypotheses are typically rejected in statistical tests if the marginal significance level is 0.05 or less.

17 Note that the asymmetric responses estimated in the third period provide strong evidence against the third of the four theories discussed in the first section dealing with inflation effects. In particular, if investors are responding to unanticipated money growth because of revised assessments of future inflation, responses would be expected to be symmetric.

money supply surprises is larger in the post-October 1979 period.[18] For example, in the cases of positive unanticipated changes when money growth exceeds the upper limit of the long-run range and negative unanticipated changes when money growth is below the lower limit of the range, the market's response (coefficients c_{11} and c_{16}) is estimated to be about 20 times larger than that of the pre-October 1979 period. This result probably reflects the market's assessment that the Federal Reserve will accommodate less of the short-run changes in money which move money growth away from the upper and lower limits of the long-run ranges. In contrast, the differences across time in the responses to three of the other four categories of unanticipated changes in money are not nearly as large, indicating that in these cases the market expects the implications of the new monetary control procedure to be about the same as the pre-October 1979 procedure.[19]

Sources of Increased Interest Rate Volatility

Because the above results indicate that the market responds differently to different types of unanticipated changes in money, the volatility of interest rates may be further decomposed to better identify the causes of its rise. The approach used in this volatility decomposition is presented in the bottom portion of Table 3. Specifically, the volatility of interest rates in the third period is made equal to the volatility in the first period, plus the rise in volatility due to changes in the volatility and category of unanticipated money, plus rises due to the changes in the market's response to both positive money surprises when money growth is above the long-run range and negative surprises when money growth is below the long-run range, plus the change in random volatility.[20]

The results in Table 3 indicate that about 34 percent of the third period's interest rate volatility from 3:30 to 5:00 p.m. on the day of a money announcement is due to an increase in the market's response to unanticipated changes in money, and most of this amount is due to positive surprises when money growth is above the upper limit of the long-run range. The value of 34 percent is obtained by summing the values in the two columns corresponding to the change

18 The hypothesis that the six estimated responses are the same across the pre- and post-October 1979 periods can be rejected at less than the 0.0001 significance level. The equations used in this test are again weighted by the reciprocals of their estimated standard errors to avoid problems associated with heteroscedasticity.

19 The hypothesis that the responses to the four middle categories of money surprises have remained the same cannot be rejected at more than the 50 percent level of significance.

20 Volatility is decomposed using the empirical relationship that includes different responses over time for money surprises which move money growth away from the boundaries of the money growth range, c_{11} and c_{16}, and constant responses over time for all other types of money surprises. The volatility decomposition may be represented analytically as

$$(1/N_3)\cdot\sum_{t=N_2+1}^{N_3}\Delta R_t^2=(1/N_1)\cdot\sum_{t=1}^{N_1}\Delta R_t^2$$
$$+\left[\sum_{i=1}^{6}\sum_{t=N_2+1}^{N_3}b_{1i}^2\cdot(1/N_3)\cdot UM_{i,t}^2-\sum_{i=1}^{6}\sum_{t=1}^{N_1}b_{1i}^2\cdot(1/N_1)\cdot UM_{i,t}^2\right]$$
$$+\left[((b'_{11})^2-(b_{11})^2)\cdot\sum_{t=N_2+1}^{N_3}(1/N_3)\cdot UM_{i,t}^2\right]$$
$$+\left[((b'_{16})^2-(b_{16})^2)\cdot\sum_{t=N_2+1}^{N_3}(1/N_3)\cdot UM_{i,t}^2\right]$$
$$+\left[(1/N_3)\cdot\sum_{t=N_2+1}^{N_3}e_t^2-(1/N_1)\cdot\sum_{t=1}^{N_1}e_t^2\right]$$

where $b_{1i}(i=1,\ldots,6)$ = estimated coefficients in the first period

$b'_{1i}(i=1,\ldots,6)$ = estimated coefficients in the third period

N_1, N_2, N_3 = number of observations in the first, second, and third periods, respectively.

Table 3
FEDERAL RESERVE MONETARY TARGETS AND THE MARKET'S RESPONSE TO UNANTICIPATED MONEY*

$$\Delta R_t = c_{11} \cdot UM^{+}_{a,t} + c_{12} \cdot UM^{-}_{a,t} + c_{13} \cdot UM^{+}_{w,t} + c_{14} \cdot UM^{-}_{w,t} + c_{15} \cdot UM^{+}_{b,t} + c_{16} \cdot UM^{-}_{b,t} + u_t$$

Estimation Period	Estimated Coefficients						Summary Statistics			Test Statistics†	
	c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{16}	$\bar{R}^2$	SE	DW	F-Statistic	Marginal Significance
9/29/77-10/4/79	0.0076 (0.0051)	0.0308 (0.0100)	0.0257 (0.0086)	0.0049 (0.0043)	0.0006 (0.0149)	0.0032 (0.0041)	0.12	0.038	1.94	2.306	0.050
2/8/80-11/20/81	0.1433 (0.0251)	0.0545 (0.0604)	0.0472 (0.0225)	0.0212 (0.0287)	0.0351 (0.0150)	0.0704 (0.0171)	0.38	0.197	2.01	3.262	0.010

Decomposition of Interest Rate Volatility in Period III (2/8/80-11/20/81)

	Volatility in Period III	=	Volatility in Period I	+	Change in Volatility and Type of Unanticipated Money	+	Change in Market's Response to UM_a^+	+	Change in Market's Response to UM_b^-	+	Change in Random Volatility
Mean-Square Error	0.0618		0.0016		0.0013		0.0137		0.0072		0.0380
Percent of Mean-Square Error	100.0		2.6		1.9		22.2		11.7		61.7

*See the notes in Table 2.

†The null hypothesis of the test corresponds to $c_{11} = c_{12} = c_{13} = c_{14} = c_{15} = c_{16}$.

$UM^{+}_{a,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is above the upper limit of the long-run policy range and the surprise is positive, zero otherwise

$UM^{-}_{a,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is above the upper limit of the long-run policy range and the surprise is negative, zero otherwise

$UM^{+}_{w,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is within the long-run policy range and the surprise is positive, zero otherwise

$UM^{-}_{w,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is within the long-run policy range and the surprise is negative, zero otherwise

$UM^{+}_{b,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is below the lower limit of the long-run policy range, and the surprise is positive, zero otherwise

$UM^{-}_{b,t}$ = $\Delta M_t - \Delta M^e_t$ if money growth is below the lower limit of the long-run policy range and the surprise is negative, zero otherwise

in the market's response. Changes in the volatility and type of money surprises amount to about 2.0 percent of the interest rate volatility in period III, where a money surprise's type refers to the six categories of unanticipated money characterized by its sign as well as the relation of money growth to the long-run range.

One implication of these empirical findings is that if the market had not perceived a greater commitment on the part of the Federal Reserve to control money, the volatility of the 3-month Treasury bill yield would have been about 34 percent less. Thus, contrary to the opinions expressed by some observers, greater interest rate volatility is due in part to an increased effort by the Federal Reserve to control money growth, not the opposite. Alternatively, if money recorded growth within its long-run ranges throughout the third period, interest rate volatility would have again been about 34 percent less because of the lower responsiveness of interest rates when money growth is within the long-run range. Nevertheless, this latter result does not imply that a more aggressive short-run monetary policy by the Federal Reserve would have been capable of producing less volatility. Indeed, available evidence suggests that closer monetary control during this period might have led to larger, not smaller, fluctuations in short-term interest rates.[21] Moreover, in comparison to the period before the introduction of the reserve-aggregate monetary control procedure, interest rates would nevertheless have recorded a substantial increase in volatility even if money growth happened to fall within its long-run range.

21 See, for example, Bryon Higgins, "Should the Federal Reserve Fine Tune Monetary Growth?" *Economic Review*, Federal Reserve Bank of Kansas City, January 1982, pp. 3-16.

CONCLUSIONS

The last three years have witnessed an accelerated pace of financial innovation and regulatory change as well as large fluctuations in total economic output and its components. In addition, as financial observers are quick to point out, the last three years also have been a time of increased volatility of short-term interest rates.

The increase in the volatility of interest rates since late 1979 was examined in this article. This rise was investigated in the context of the change in the 3-month Treasury bill yield from 3:30 to 5:00 p.m. on the day of a weekly money announcement, which spans the 4:10 p.m. time of the announcements. By examining the movements in short-term interest rates during these hour and a half periods, the direct effects of the Federal Reserve's adoption of a reserve-aggregate approach to money control on October 6, 1979 was estimated.

An efficient markets model was used to estimate the impact of the new monetary control procedures on interest rate volatility. This model relates the unanticipated component of each week's announced change in money to an associated change in interest rates. The estimation results of this model indicated that short-term interest rates have, on average, become more responsive to unanticipated changes in money. Moreover, the results suggest that about 34 percent of the volatility of the 3-month Treasury bill yield since October 1979 may be directly attributed to an increase in the market's response to unanticipated changes in the money supply. If the Federal Reserve's new operating procedures caused this increased response, then this estimate corresponds to the direct impact of the policy implementation change.