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Money Supply Announcements and Interest Rates: Another View*

This paper examines the impact of money supply announcements on the entire term structure of interest rates. After October 6, 1979, a significant positive correlation is found between announced money supply innovations and changes in the yields on government securities of all maturities. This finding calls into question the view that rates rise in response to an unexpected increase in the money supply because market participants interpret the jump as a signal that the Federal Reserve Board will tighten in the future. While expected future monetary restriction may drive up short rates, it should not have the same effect on long rates.

I. Introduction

In this paper I use a new approach to analyze the impact of money supply announcements on the bond market. Before 1980, the only available work on this subject consisted of a few unpublished papers by Conrad (1978), Sivesind (1978), and Urich (1979).[1] More recently, published papers by Grossman (1981) and Urich and Wachtel (1981) have appeared. Roley (1982) extends the Grossman study to incorporate data after the Federal Reserve policy statement of October 6, 1979.

Both Grossman and Urich and Wachtel are primarily concerned with the question of money market efficiency. Using survey data made available by Money Market Services of San Francisco and data on Treasury bill yields each finds that the market responds quickly to unanticipated changes in the money supply but that anticipated changes have no effect on interest rates. In addition, Grossman finds that when he adds other variables, such as past changes in the money

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1. In a previous study (Cornell 1979), I briefly looked at money supply announcements, but the objective was to illustrate a technique I had developed for measuring the impact of announcements by using estimates of the variance of price changes.

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stock, to a regression of the change in the interest rate on the unanticipated change in the money supply, the added variables are always insignificant. Both papers reach the conclusion that the Treasury bill market is efficient with respect to the information contained in money supply announcements. Roley (1982) extends Grossman's sample period and reaches the same conclusion regarding market efficiency.

Urich and Wachtel (1981) also attempt to explain why the market reacts to money supply announcements. They note that interest rates and money supply announcements could be related via three different channels. First, standard Keynesian theory predicts that actual monetary expansion leads to lower interest rates through the liquidity effect. Second, it is possible that interest rates respond to anticipations of future policy changes. Finally, money supply announcements may affect nominal interest rates directly through their impact on expected inflation.

As described by Dornbusch (1976) and others, the liquidity effect operates through the demand for money. The argument is most easily illustrated by assuming that the money demand function takes the simple form given by equation (1).

$$M/P = f(Y, r), \tag{1}$$

where M = the nominal stock of money, P = the price level, Y = the level of real income, and r = the short-term interest rate. A liquidity effect exists because the price level does not respond instantaneously to monetary shocks. For this reason, the interest rate must adjust to clear the money market. A sudden increase in the supply of nominal money balances, for instance, will cause real money balances to rise because prices are sluggish. To clear the money market, therefore, the interest rate must fall to produce an offsetting increase in money demand. The liquidity effect is a short-run phenomenon. As Dornbusch (1976) carefully notes, the interest rate starts to return to its initial level as soon as prices begin to adjust. When the adjustment of prices is complete, interest rates will have returned to their starting point.

Urich and Wachtel correctly observe that an actual liquidity effect cannot possibly explain the relation between changes in interest rates and money supply announcements. The announcements, made at the end of the week, provide data on the money supply on Wednesday of the previous week. Any change in the interest rate caused by an actual change in the money supply should have occurred when the money supply was altered, not at the time of the subsequent announcement.

It is possible, nonetheless, that money supply announcements lead to anticipations of future policy changes. These expected policy changes, in turn, may affect interest rates. For example, if agents expect a future period of monetary restraint and accompanying higher interest rates, they will bid aggressively for funds and drive up the current interest rate. Urich and Wachtel refer to this scenario as the "policy anticipation effect."

It should be noted that the policy anticipation effect combines two elements. First, it is postulated that the Fed has certain monetary targets. Second, it is assumed that a liquidity effect exists and that market participants are aware of this fact. Given these assumptions, suppose that the announced change in the money supply exceeds expectations. Market participants are likely to conclude that the Fed will have to counteract the unexpected jump by pursuing a more restrictive monetary policy. This leads to higher interest rates because of the *expected* future liquidity effect. Thus the policy anticipation effect implies that changes in interest rates and announced monetary innovations will be positively correlated. Both Grossman (1981) and Urich and Wachtel (1981) find evidence of the predicted positive correlation. In addition, the policy anticipation effect implies that unexpected increases in the money supply will have a larger effect on interest rates when they push money growth rates above the Fed's upper target, and unexpected decreases will have a larger effect on interest rates when they push money growth rates below the Fed's lower target. The evidence presented by Urich and Wachtel is consistent with these predictions. Last, Urich and Wachtel note that the policy anticipation effect should be stronger during periods when the Fed is stressing the importance of controlling monetary aggregates. Once again they find that the evidence is consistent with their hypothesis.

There is a related explanation which Urich and Wachtel overlook. Presently, reserve requirements are based on deposits held 2 weeks earlier. As figure 1 shows, money supply announcements occur with a 9-day lag, so that the Friday afternoon release provides the market with information about the current aggregate demand for reserves. If an unexpected increase in the money supply is announced, bankers realize that the aggregate demand for reserves in the remainder of the reserve week will be larger than predicted. The resulting scramble for reserves drives up interest rates via the liquidity effect if the Fed does not accommodate it by increasing the supply of reserves.

Finally, the positive correlation between interest rate changes and announced money supply innovations can be explained in terms of changing inflation expectations. For example, an unexpected increase in the money supply may lead market participants to believe that the

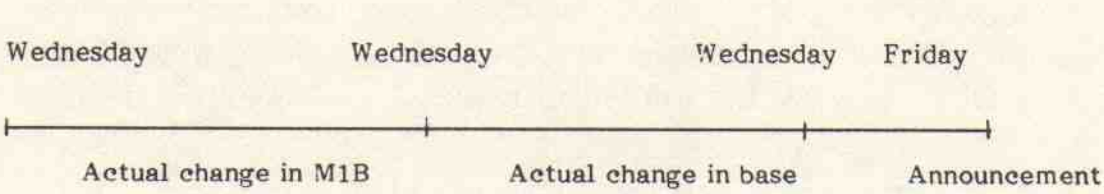

FIG. 1.—Time line for money supply announcements

Fed's resolve to fight inflation has weakened. If the increase pushes the growth rate of the money supply above the Fed's upper target, this serves to increase investors' conviction that the Fed has changed its policy. Finally, if the increase occurs during a period when the Fed is stressing the importance of controlling monetary aggregates, investors may become even more certain that the Fed has revised its targets. Urich and Wachtel dismiss these explanations. They claim that "although increases in the money supply can lead market participants to revise upward their expectations of inflation, such responses are gradual and delayed" (p. 1064). Since expected inflation adjusts slowly, in their view, changing expectations cannot possibly explain the immediate response of interest rates to money supply announcements. Such a view is surprising in the light of Urich and Wachtel's findings on market efficiency. In an efficient market, as Fama (1970) notes, market participants should instantaneously adjust their expectations when new information arrives.

There is another reason for not dismissing the expected inflation explanation so quickly. In a series of papers beginning with Fama (1975), Hess and Bicksler (1975), Nelson and Schwert (1977), and Fama and Gibbons (1982) all conclude that during the period from 1953 to 1971 most of the variation in nominal interest rates was attributable to changing inflation expectations. Fama and Gibbons (1982) claim further that the variation in the real rate that does occur is due to the need to induce equilibrium shifts of resources between consumption and investment. If the liquidity effect does not have a significant impact on interest rates, then the policy anticipation effect cannot be empirically important, because it is premised on the existence of a liquidity effect.

Some puzzling questions remain, therefore, about the response of interest rates to money supply announcements. The issue, furthermore, is not limited to the question of market efficiency but involves problems at the core of monetary theory, such as the mechanism by which monetary policy affects nominal interest rates. The goal of this paper is to extend the work of Grossman and of Urich and Wachtel with the hope of providing insight into the relationship between money and interest rates. Before turning to that, however, there is one more paper that must be mentioned.

In a study of the demand for money, Fama (1982) finds that the monetary aggregate most highly correlated with the rate of inflation is the monetary base rather than one of the more comprehensive measures like M1B.[2] If this is true, and if changing inflation expectations are the main source of variation in nominal interest rates, then an-

2. The Fed recently gave M1B a new name, M1, which was originally used for a slightly different monetary aggregate.

nounced innovations in the monetary base may have a larger impact on interest rates than innovations in M1B.

The Fama article suggests my first extension of the previous research on money supply announcements and interest rates; innovations in both the base and M1B are computed in this paper and their correlations with changes in interest rates are compared. Because previous studies focused exclusively on the response of short-term interest rates to money supply announcements, they could not adequately distinguish the policy anticipation effect from the effect of changing inflation expectations. In this paper, I extend the previous work by examining the response of the entire term structure to money supply announcements.

Shiller (1979) shows that linearization of all well-known theories of the term structure can be represented by an equation of the form

$$R_n^t = (1 - k)/(1 - k^n) \sum_{j=0}^{n-1} k^j E_t(r_{t+j}) + L_n, \tag{2}$$

where R_n^t = the yield at time t on an n-period bond, r_t = the yield at time t on a 1-period bond, k = a constant between 0 and 1, and L_n = a constant "term premium." Equation (2) implies that if the policy anticipation effect is correct, money supply announcements should have a markedly different impact on short-term interest rates than on long-term interest rates. There are two possible cases. In the first instance, the anticipated period of monetary restraint is expected to be short-lived. In that case only the spot rate and nearby forward rates would be affected, so that the impact on 30-year yields would be minimal. On the other hand, if the anticipated period of monetary restraint is expected to be prolonged, distant forward rates, and hence long-term rates, will fall. The drop occurs because the liquidity effect is short-lived and because a prolonged period of monetary restraint would eventually reduce expected inflation. (I do not mean to rule out the view that expected inflation would adjust immediately; my point is simply to stress that economists of all persuasions would accept the proposition that prices and expectations respond in the long run.) Similarly, the reserve demand effect discussed earlier applies only to the current reserve week and should have little impact on long rates.

While effects that rely on a sluggish price level must be temporary, changes in expected inflation may be permanent. If money supply announcements produce a permanent change in expected inflation, then the entire term structure will shift. Of course, the expected inflation approach does not necessarily imply that the term structure will respond in this manner, because the change in inflation expectations may not be permanent. Nonetheless, added insight into the behavior of interest rates can be gained by examining the response of the entire term structure to money supply announcements.

Lastly, there is the practical problem of measuring unexpected changes in the monetary aggregates. Like Urich and Wachtel, I take two approaches. The first is to use the residuals from an autoregressive model derived from the time series of weekly money supply changes. The second approach is to employ survey data made available by Money Market Services of San Francisco. The unexpected change in the second case is defined to be the difference between the actual change and the median forecast change. (The median forecast is all that Money Market Services makes public.)[3]

The remainder of the paper is organized as follows. In the next section, the monetary data are analyzed and the autoregressive models are estimated. In Section III the relation between residuals from the autoregressive models and changes in interest rates on federal funds, 3-month Treasury bills, 1-year Treasury bills, 5-year Treasury notes, and 30-year Treasury notes is studied. The Money Market Services data are presented in Section IV and the analysis of Section III is repeated. In the fifth section an explanation of the results is offered. The final section contains the conclusions and a summary of the results.

II. The Weekly Money Supply Announcements

The data used in this study are the actual announcements of the seasonally adjusted monetary base and the seasonally adjusted money stock. The effect of subsequent revisions to the original announcements is not considered. This means that some information made available on announcement day is ignored, because the Fed simultaneously makes public both the latest money supply figures and the revisions, if any, in the previous week's figures. In his study of the reaction of the Treasury bill market, Roley (1982) finds that taking account of the revisions has little impact on his results.

The sample covers the period from January 5, 1978, to August 28, 1981. Unfortunately, data on M1B are not available before the week of February 8, 1980, so I was forced to use data on M1 for the first part of the sample. The change in the money supply for the week in which the switch from M1 to M1B occurred is excluded. Because no further adjustments are made, I am implicitly assuming that announcements of the change in M1 and the change in M1B have a similar impact on the interest rates. Henceforth, I refer to the money supply as M1B with the understanding that it is actually M1 for the early part of the sample.

In the week of February 8, 1980, the Fed changed the normal an-

3. In the light of rational expectations theory, a third approach would be to derive a complete model of the money supply process and then to identify expectations with the forecasts of the model. This approach has been employed by Barro (1977, 1978), but it is not feasible with weekly data.

nouncement time from Thursday afternoon to Friday afternoon. In several cases, furthermore, the announcements were postponed to the next working day because of a holiday. For this reason the observation interval is not exactly 1 week in every case, but no adjustments are made for this effect. The actual announcement day is simply recorded so interest rate changes can be calculated over the corresponding interval.

The autocorrelation functions for changes in the base and changes in M1B are reported in table 1.[4] Autocorrelations are computed for the full sample and for three subsamples: the period before October 6, 1979, the period after October 6, 1979, and the most recent year. For the full sample, and for all the subsamples, changes in the monetary base exhibit significant, negative, first-order autocorrelation. There is also evidence of positive, second-order autocorrelation in the period before October 6, 1979. The changes in M1B exhibit less autocorrelation than changes in the base. This is no doubt due in part to the larger variance of this series. Nonetheless, there remains evidence of negative, first-order autocorrelation throughout the sample.[5]

For each period, the time-series models are estimated using all available data. This means that the models incorporate information that was not available to market participants when they made their investment decisions. A more appropriate approach would be to estimate the models using only data that were available to investors at the time. Unfortunately, this means that the estimates would have to be updated every week. Limited computer funds and research assistance rendered this approach impractical.

Because information not available to market participants is used in the estimation, it is particularly important to avoid "data mining." For example, tailoring a different model to every subsample may succeed only in highlighting the random realizations unique to each sample, rather than revealing the underlying stochastic process. To avoid this problem I use a conservative procedure. After examining the autocorrelation functions and the partial autocorrelation functions (which are not presented here), I decided that either an ARIMA (1,1) or an ARIMA (0,2) model would be appropriate for all the sample periods.[6] These models are given by equations (1) and (2), respectively.

$$DM_t = a_1 DM_{t-1} + \mathbf{m} + u_t - a_2 u_{t-1}, \qquad (3)$$

4. Actual changes rather than percentage changes are used in the analysis since most people think in terms of the actual change. The results are essentially identical growth rates. Given the relatively slow growth of the monetary aggregates and the short sample period, using actual changes does not introduce detectable nonstationarity.

5. Part of the negative first-order autocorrelation may be due to measurement error despite the fact that the data were carefully examined for suspicious reversals.

6. For a description of the notation and an explanation of the technique used here, see Box and Jenkins (1970) or Nelson (1973).

TABLE 1 Autocorrelation Functions

Period	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	Mean	SE
	Monetary Base: Weekly Changes in Billions											
Full sample	−.48	.21	−.09	.01	−.02	.09	−.07	.07	−.01	−.01	.201	.662
Pre–October 6	−.59	.32	−.12	.00	.02	−.07	.01	.04	−.03	−.01	.226	.534
Post–October 6	−.43	.16	−.08	.02	−.03	.15	−.10	.08	−.01	.00	.178	.764
Latest year	−.36	.09	−.13	.02	−.04	.19	−.22	.24	−.23	.13	.104	.870
	Money Supply (M1B): Weekly Changes in Billions											
Full sample	−.22	−.16	−.06	.14	.07	−.02	−.11	.01	.13	−.11	.441	2.42
Pre–October 6	−.17	−.23	−.03	.14	.16	−.07	−.07	−.09	.13	−.02	.438	2.06
Post–October 6	−.25	−.11	−.06	.13	.02	.02	−.11	.05	.13	−.16	.444	2.73
Latest year	−.23	−.19	−.05	.09	.04	−.09	−.11	.15	.05	−.23	.543	2.99

NOTE.—Full sample: January 5, 1978–August 28, 1981; pre–October 6: January 5, 1978–October 4, 1979; post–October 6: October 11, 1979–August 28, 1981; latest year: September 5, 1980–August 28, 1981.

$$DM_t = \mathbf{m} + u_t - b_1 u_{t-1} - b_2 u_{t-2}, \tag{4}$$

where DM_t = the change in the monetary aggregate, $\mathbf{m}$ = the mean of the process, u_t = the error terms, and a_i,b_i = the parameters to be estimated. The two models were estimated for each sample period and the one which worked the best, in the sense of producing white noise residuals and having the smallest residual sum of squares was selected. Since both models succeeded in whitening the residuals in every case, no further estimation was undertaken.

The estimation results are reported in table 2 for both M1B and the monetary base. As expected from inspection of the autocorrelation functions, the coefficients have higher t-statistics in the base equations. The equations were not reestimated even if one of the coefficients was found to be insignificant.

III. Empirical Results Using the Autoregressive Models

The interest rate data were provided by the Federal Reserve Bank of San Francisco. The sample consists of daily closing observations on the federal funds rate, the 3-month Treasury bill rate, the 1-year Treasury bill rate, the 5-year Treasury note rate, and the 30-year Treasury bond rate over the period from January 5, 1978, to August 28, 1981. The data are converted to continuously compounded annual rates of return.

The 30-year bond rate is actually an index computed by the Federal Reserve, which introduces added measurement error. Fortunately, measurement error will not produce spurious correlations in this study (assuming, of course, that the errors are uncorrelated with each other). To the extent that the change in the interest rate or the announced innovation in the money supply is measured with error, the estimated correlation between the two variables will be biased toward zero.

In an attempt to eliminate obvious errors, the data were differenced and outliers were checked against similar data provided by Saloman Brothers. Though this procedure uncovered errors that occurred when the data were entered into the UCLA computer, no errors in the Fed's sample were found.[7]

The closing quotes are all from approximately 3:30 P.M. (EST), which is over half an hour before the money supply announcement at 4:10 P.M. The change in the interest rate, therefore, is measured from the close just before the money supply announcement to the close the day after the announcement. Both Grossman and Urich and Wachtel use a shorter observation interval. Grossman measures the change in

7. The Saloman Brothers data are not identical to the Fed data, so the cross check was used only to test for large discrepancies.

TABLE 2 ARIMA Models

	Change in Monetary Base (DB)	Change in M1B (DM)
Full sample	$DB_t = -.45\ DB_{t-1} + .20 + e_t - .04\ e_{t-1}$ $(-3.3)\quad(7.1)\quad(-.2)$	$DM_t = .23\ DM_{t-1} + .46 + e_t - .56e_{t-1}$ $(1.4)\quad(4.8)\quad(-3.8)$
Pre–October 6	$DB_t = -.57\ DB_{e-1} + .23 + e_t - .04\ e_{t-1}$ $(-.39)\quad(8.1)\quad(-.2)$	$DM_t = 290M_{t-1} + .49 + e_t - .60e_{t-1}$ $(1.4)\quad(4.1)\quad(-3.3)$
Post–October 6	$DB_t = -.35\ DB_{t-1} + .18 + e_t - .10e_{t-1}$ $(-1.6)\quad(3.7)\quad(-.5)$	$DM_t = .18\ DM_{t-1} + .45 + e_t - .52e_{t-1}$ $(0.7)\quad(2.9)\quad(-2.3)$
Latest year	$DB_t = .10 + e_t - .41e_{t-1} + .06\ e_{t-2}$ $(1.4)\quad(2.9)\quad(.4)$	$DM_t = -.54 + e_t - .38e_{t-1} - .21e_{t-2}$ $(2.7)\quad(-2.7)\quad(1.4)$

NOTE.—t-statistics in parentheses.

TABLE 3 Cross-Correlation Functions Using Base ARIMA Residuals

Base Residuals vs. Change in Selected Interest Rates	ρ_{-3}	ρ_{-2}	ρ_{-1}	ρ_0	ρ_1	ρ_2	ρ_3	SE
				Full Sample				
BR vs. *DFF*	−.03	.18	−.20	.11	.13	−.07	.15	.07
BR vs. *DTB*	.00	.11	−.06	.04	.03	−.17	.08	.07
BR vs. *DYB*	.00	.11	.05	.10	.08	.09	.11	.07
BR vs. *DN*	.03	.06	.08	.05	.10	−.03	.06	.07
BR vs. *DB*	.14	−.05	−.01	.07	.01	−.05	.14	.07
				Pre–October 6 Sample				
BR vs. *DFF*	.19	.22	−.12	.31	.10	.07	.06	.11
BR vs. *DTB*	−.02	.08	.05	.00	.11	.14	−.12	.11
BR vs. *DYB*	.02	−.02	.29	.13	.05	.18	−.05	.11
BR vs. *DN*	.04	−.15	.17	.09	.13	.18	.06	.11
BR vs. *DB*	.05	−.01	.21	.12	.06	.26	−.06	.11
				Post–October 6 Sample				
BR vs. *DFF*	−.08	.18	−.21	.07	.15	−.11	.17	.10
BR vs. *DTB*	.00	.13	−.07	.04	.03	−.21	.09	.10
BR vs. *DYB*	−.01	.14	.02	.09	.10	−.13	.11	.10
BR vs. *DN*	.04	−.06	−.10	.04	.10	−.06	.04	.10
BR vs. *DB*	.05	.13	.03	.07	.02	−.08	.15	.10
				Latest Year				
BR vs. *DFF*	−.15	.20	−.39	.13	.03	−.15	.16	.14
BR vs. *DTB*	−.11	.19	−.16	.05	−.06	−.25	.15	.14
BR vs. *DYB*	−.08	.17	−.11	.10	.05	−.19	.13	.14
BR vs. *DN*	.01	.19	−.14	.03	−.03	−.17	.13	.14
BR vs. *DB*	.00	.19	−.09	.10	−.05	−.08	.17	.14

NOTE.—*DFF* = change in federal funds rate; *DTB* = change in 3-month bill rate; *DYB* = change in 1-year bill rate; *DN* = change in treasury note rate; *DR* = change in treasury bond rate; *BR* = residuals from autoregressive model for the base; *SE* = standard error of the estimate of the correlation.

the interest rate from 3:30 P.M. to 5:00 P.M. The 5:00 P.M. quotes are reported by Telerate and include trades that occur after the money supply announcement. Urich and Wachtel, on the other hand, measure the change from the 3:30 close to the next morning's opening. Because data on securities of all maturities are not available for either of these shorter intervals, I use the close-to-close figures. This means that the variance of the change in the interest rate will be larger for my sample. Since the increase in variance is unrelated to the money supply announcements, the estimated correlations will tend to be lower than those for a shorter observation interval.

Cross correlations between the change in interest rates and the autoregressive residuals are reported in table 3 for the base and in table 4 for M1B. The lags and leads give the correlation between current

TABLE 4 Cross-Correlation Functions Using M1B ARIMA Residuals

Money Supply Residuals vs. Change in Selected Interest Rates	ρ_{-3}	ρ_{-2}	ρ_{-1}	ρ_0	ρ_1	ρ_2	ρ_3	SE
				Full Sample				
MR vs. *DFF*	.12	−.07	.10	.20	−.13	.19	−.06	.07
MR vs. *DTB*	.05	.12	.09	.37	.01	.18	.04	.07
MR vs. *DYB*	.08	.09	.11	.43	.07	.10	.04	.07
MR vs. *DN*	.04	.07	.09	.37	.04	.16	.00	.07
MR vs. *DB*	.09	.04	.11	.34	.02	.08	−.01	.07
				Pre–October 6 Sample				
MR vs. *DFF*	.01	−.02	.26	.01	−.05	.14	.06	.11
MR vs. *DTB*	.04	.06	−.08	.24	.09	−.02	−.13	.11
MR vs. *DYB*	−.02	.04	.03	.25	.15	.02	−.14	.11
MR vs. *DN*	.18	.04	.04	.04	.18	.22	−.16	.11
MR vs. *DB*	−.03	.08	.00	.25	.29	.00	−.20	.11
				Post–October 6 Sample				
MR vs. *DFF*	.15	−.10	.06	.24	−.17	.19	−.09	.10
MR vs. *DTB*	.06	.14	.13	.43	.00	.24	.09	.10
MR vs. *DYB*	.10	.10	.14	.50	.06	.13	.09	.10
MR vs. *DN*	.04	.06	.11	.46	.02	.18	.04	.10
MR vs. *DB*	.11	.04	−.14	.39	−.02	.10	.02	.10
				Latest Year				
MR vs. *DFF*	.26	−.05	.06	.32	−.21	.31	−.06	.14
MR vs. *DTB*	.07	.17	.13	.41	.03	.25	.07	.14
MR vs. *DYB*	.16	.15	.15	.46	.13	.13	.08	.14
MR vs. *DN*	.06	.11	.19	.52	.02	.12	.00	.14
MR vs. *DB*	.21	.15	.13	.41	.07	.08	.03	.14

NOTE.—See table 3 n.; *MR* = residuals from autoregressive model for the money supply.

changes in interest rates and past and future money supply innovations. Perhaps the most striking result to emerge from the tables is that there is no noticeable relationship between unexpected changes in the monetary base and changes in interest rates on securities of any maturity. Of the 120 estimated correlation coefficients only 10 are significant at the 5% level. The few significant coefficients, furthermore, do not fall into a pattern and appear to be due to sampling variation. Finally, there is no tendency for significant coefficients to occur with greater frequency either before or after October 6, 1979.

The results for M1B reported in table 4 are markedly different. All the contemporaneous correlations are positive and significant for the full sample. The correlations for lags and leads, on the other hand, are typically insignificant and do not fall into any particular pattern. Thus the results are consistent with market efficiency in the sense that the information contained in money supply announcements is discounted during the week of announcement. The results are also consistent with Grossman's finding that lagged innovations in the money supply are insignificant when included in a regression model with the current innovation.

Examining the contemporaneous correlations, a marked shift is observed on October 6, 1979. Prior to that date, the correlations for federal funds and Treasury notes were insignificant and the correlations for the other three securities were only marginally significant. After October 6 the correlations rise dramatically; all the correlations are highly significant, and with the exception of Fed funds all are close to .50. Results for the latest year, which runs from September 1980 to August 1981, are indistinguishable from the post–October 6, 1979, period as a whole. Though a marked shift in the relation between interest rates and money supply announcements occurred when the Fed proclaimed its proposed change in operating procedure, there is no evidence of any further shifts in the subsequent 2 years.

Comparing the results for securities of different maturities, the correlations are seen to be remarkably similar. The only exception is the federal funds rate, which is lower, but this is no doubt due in part to the high variance of changes in the funds rate. Consistent with the findings of Grossman and Urich and Wachtel, all the correlations are positive, indicating that an unexpected increase in the money supply is associated with an increase in interest rates. What is surprising is that the money supply announcements explain an equal fraction of the variance of changes in both short-term rates and long-term rates.

Further insight can be gained by turning to the regression results reported in table 5. Only the contemporaneous monetary innovation is included in the regressions, because the cross-correlation function reveals that lags and leads are insignificant.[8] Looking first at the monetary base regressions, most of the slope coefficients are insignificant as expected from the cross-correlation function. The only significant coefficient is in the period before October 6, and it appears to be an outlier. The regressions confirm, therefore, that innovations in the monetary base have little impact on interest rates. This is somewhat surprising in the light of Fama's (1982) finding that the base is more highly correlated with inflation than M1B.

Turning to the money supply regressions, the most interesting result comes from comparing the magnitudes of the slope coefficients for securities with different maturities. In the post–October 6 period the standard deviation of announced money supply innovations is \$2.4 billion. Defining a large unexpected change to be \$4 billion, the coefficients imply that an unexpected increase of that size will lead to a

8. Since only the contemporaneous correlations were significant, I chose to use the more familiar regression analysis rather than estimate a transfer function.

TABLE 5 Regression Results Using ARIMA Residuals

Dependent Variable	Independent Variable	a_0	$t(a_0)$	a_1	$t(a_1)$	R^2
			Full Sample			
DFF	*BR*	13.25	2.42	14.86	1.55	.013
DTB	*BR*	3.99	1.42	2.66	.50	.001
DYB	*BR*	1.66	.82	5.35	1.35	.010
DN	*BR*	1.05	.56	2.51	.71	.003
DB	*BR*	1.36	1.09	2.21	.95	.005
DFF	*MR*	13.31	2.38	6.25	2.73	.041
DTB	*MR*	4.05	1.30	6.79	5.46	.138
DYB	*MR*	1.71	.72	5.83	6.41	.181
DN	*MR*	1.09	.51	4.55	5.40	.136
DB	*MR*	1.39	1.01	2.78	5.01	.119
			Pre–October 6 Sample			
DFF	*BR*	13.10	3.70	25.22	3.06	.096
DTB	*BR*	3.42	2.39	−.15	−.05	.000
DYB	*BR*	3.23	2.91	3.11	1.21	.016
DN	*BR*	3.14	3.39	1.74	.81	.007
DB	*BR*	1.27	2.77	1.24	1.15	.015
DFF	*MR*	13.13	3.53	.09	.05	.000
DTB	*MR*	3.45	2.50	1.76	2.50	.066
DYB	*MR*	3.26	3.03	1.44	2.62	.072
DN	*MR*	3.15	3.39	.30	.63	.005
DB	*MR*	1.29	2.88	.57	2.50	.067
			Post–October 6 Sample			
DFF	*BR*	12.58	1.22	9.34	.62	.004
DTB	*BR*	4.99	.86	3.39	.40	.002
DYB	*BR*	.44	.10	5.56	.88	.008
DN	*BR*	−.86	−.22	2.21	.39	.002
DB	*BR*	1.22	.47	2.24	.59	.004
DFF	*MR*	12.53	1.25	9.48	2.44	.059
DTB	*MR*	4.95	.94	9.57	4.70	.189
DYB	*MR*	.40	.11	8.26	5.63	.250
DN	*MR*	−.88	−.25	6.85	5.02	.210
DB	*MR*	1.20	.50	3.90	4.21	.157
			Latest Year			
DFF	*BR*	−8.75	−.58	17.08	.91	.017
DTB	*BR*	10.32	1.15	3.55	.32	.002
DYB	*BR*	1.20	.18	5.93	.73	.011
DN	*BR*	1.46	.34	1.01	.19	.001
DB	*BR*	.80	.21	3.18	.68	.009
DFF	*MR*	−9.68	−.67	12.56	2.37	.105
DTB	*MR*	9.62	1.17	9.36	3.12	.169
DYB	*MR*	.62	.11	7.75	3.60	.213
DN	*MR*	1.03	.28	5.80	4.28	.276
DB	*MR*	.49	.14	4.13	3.27	.182

NOTE.—Residual autocorrelations are not reported, but in every case the residuals were very nearly white noise. This is of course to be expected, since the left-hand variable is the change in an asset price.

rise of 38 basis points in the federal funds rate, 38 basis points in the 3-month bill rate, 26 basis points in the 5-year note rate, and 16 basis points in the 30-year bond rate. Thus long-term bond rates move in the same direction as the short-term rate and by nearly half as much. A change of 16 basis points in the 30-year bond rate is economically as well as statistically significant. For a 13% coupon bond originally selling at par, an increase in yield to 13.16 implies a drop in price to 98 26/32. The price decline of 38/32 is much larger than dealers' trading costs. These results are difficult to reconcile with the policy anticipation effect.

It may seem that these results could be partially due to the daily seasonal interest rates documented by Gibbons and Hess (1981). Gibbons and Hess find that the Friday-to-Monday return on Treasury bills is lower than for other daily intervals. The mean difference, however, is small compared with the effect documented here. More important, the seasonal pattern cannot explain the cross-sectional relation between interest rate changes and money supply innovations. On the other hand, the results reported here imply that the variance of return on bonds of all maturities will be larger for the Friday-to-Monday interval than any other interval.

IV. Results Using Survey Data

Each week since September 1977, Money Market Services of San Francisco has conducted a survey of money market traders and economists and compiled their forecasts for the change in M1B (or previously M1). Between 50 and 60 individuals are surveyed by telephone each Tuesday. The median forecast is made public by Money Market Services after the money supply announcement. The data used here are the time series of weekly median forecasts. The fact that the survey is taken on Tuesday increases the error in measuring expectations, because forecasts are likely to be revised before Friday afternoon. As noted earlier measurement error of this type makes it less likely that the null hypothesis will be rejected. Unfortunately, the survey covers only the money supply, so no data are available for the monetary base.

Tables 6 and 7 are comparable with tables 4 and 5 except that the forecast error, defined as the actual change minus the median forecast, is substituted for the autoregressive residuals. Looking at the two sets of tables, the most striking characteristic is their similarity. Comparing tables 4 and 6 first, the contemporaneous correlations are seen to be almost identical. The only difference is that the survey data produce slightly higher correlations, in general, than the autoregressive models. This finding is consistent with the view that market participants use information other than past money supply changes in computing their

TABLE 6 Cross-Correlation Functions Using Survey Forecast Errors

Forecast Errors (*FE*) vs. Changes in Selected Interest Rates	ρ_{-3}	ρ_{-2}	ρ_{-1}	ρ_0	ρ_1	ρ_2	ρ_3	SE
				Full Sample				
FE vs. *DFF*	.19	−.06	.09	.29	−.10	.22	−.02	.07
FE vs. *DTB*	.03	.03	.05	.42	−.00	.11	.11	.07
FE vs. *DYB*	.04	−.01	.05	.48	.06	.05	.05	.07
FE vs. *DN*	.06	.04	.03	.40	.03	.05	−.02	.07
FE vs. *DB*	.11	.03	.05	.42	.03	.01	.01	.07
				Pre–October 6 Sample				
FE vs. *DFF*	.11	−.03	.16	.03	−.08	.07	.13	.11
FE vs. *DTB*	.00	.05	−.14	.29	.06	−.03	−.03	.11
FE vs. *DYB*	.00	−.07	.01	.28	.16	.08	−.07	.11
FE vs. *DN*	.05	.07	.07	.06	.25	.18	−.19	.11
FE vs. *DB*	−.07	.08	−.05	.18	.27	−.01	−.13	.11
				Post–October 6 Sample				
FE vs. *DFF*	.21	−.07	.08	.36	−.12	.24	−.05	.10
FE vs. *DTB*	.05	.05	.08	.47	−.03	.15	14	.10
FE vs. *DYB*	.10	.07	.07	.56	.05	.07	.08	.10
FE vs. *DN*	.08	.04	.04	.49	−.01	.05	.00	.10
FE vs. *DB*	.14	.03	.07	.48	.00	.01	.03	.10
				Latest Year				
FE vs. *DFF*	.30	−.10	.10	.32	−.16	.25	−.06	.14
FE vs. *DTB*	.05	−.01	.11	.44	−.05	.12	.11	.14
FE vs. *DYB*	.14	.05	.04	.50	.06	.04	.07	.14
FE vs. *DN*	.05	−.01	.05	.52	−.03	.01	−.03	.14
FE vs. *DB*	−.16	−.14	.04	.46	.02	.00	.05	.14

forecasts and that this added information is reflected in the median forecasts. With a better proxy for the unexpected change in the money supply, the downward bias produced by measurement error is reduced and the estimated correlation rises.

The same pattern is repeated in tables 5 and 7. Though the estimated regression coefficients are similar in the two tables, they are higher, on average, when the survey data are used. The survey results for the post–October 6 period imply that an unexpected increase of $4 billion in the money supply will lead to an increase of 60 basis points in the federal funds rate, 44 basis points in the 3-month bill rate, 38 basis points in the 1-year bill rate, 32 basis points in the 5-year note rate, and 20 basis points in the 3-year bond rate. For a 13%-coupon, 30-year bond selling at par, an increase in yield of 20 basis points is equivalent to a price drop of about 48/32. Thus the tendency for an unexpected increase in the money supply to shift the entire term structure upward emerges even more strongly from the survey data.

TABLE 7 Regression Results Using Survey Forecast Errors as Independent Variables

Dependent Variable	a_0	$t(a_0)$	a_1	$t(a_1)$	R^2
			Full Sample		
DFF	14.73	2.74	10.59	4.09	.084
DTB	5.17	1.84	8.41	6.23	.176
DYB	2.68	1.32	7.30	7.46	.230
DN	1.81	.94	5.44	5.89	.161
DB	1.89	1.52	3.76	6.32	.179
			Pre–October 6 Sample		
DFF	12.87	3.32	.58	.25	.001
DTB	4.65	3.30	2.73	3.20	.084
DYB	4.17	3.79	2.09	3.13	.078
DN	3.36	3.49	.50	.85	.004
DB	1.51	3.21	.53	1.86	.032
			Post–October 6 Sample		
DFF	10.37	1.08	15.15	3.81	.130
DTB	3.37	.66	11.10	5.22	.229
DYB	−1.00	−.28	9.89	6.60	.314
DN	−2.00	−.58	7.86	5.51	.242
DB	.48	.21	5.10	5.41	.237
			Latest Year		
DFF	−11.91	−.82	14.03	2.35	.109
DTB	7.84	.96	10.96	3.28	.205
DYB	−.95	−.16	9.52	4.04	.255
DN	−.09	−.02	6.84	4.58	.305
DB	−.42	−.13	5.40	3.96	.247

V. Interpretation of the Results

To review the results briefly, a highly significant positive correlation was found between unexpected changes in M1B and changes in the interest rates on securities of all maturities. On closer inspection, the relationship is seen to be much stronger after October 6, 1979. Before that date the correlations are only marginally significant. The same relationship is *not* observed for the unexpected changes in the monetary base. Innovations in the base had little impact on interest rates either before or after October 6.

The findings for the base are apparently inconsistent with the joint hypothesis that inflation expectations are the primary determinant of nominal interest rates and that the base is the monetary aggregate most highly correlated with inflation. As I noted in the introduction, this joint hypothesis, combined with the assumption of rationality, seems to imply that market participants would find monetary base innovations more informative than innovations in M1B, but the empirical results do not support this interpretation. There are, however, two possible ways to explain the apparent contradiction. First, suppose that although the Fed conducts monetary policy in terms of the base, and although the base is more highly correlated with inflation than M1B, the Fed sets its policy goals in terms of the growth rate of M1B. In that case rational agents would come to realize that announcements of M1B would be more useful in predicting the future growth rate of the base than announcements of the base itself. This interpretation is consistent with the behavior of the Federal Open Market Committee (FOMC) in 1980 as described by Gilbert and Trebing (1981). They note that "the committee votes on growth rates of the monetary aggregates, not reserve aggregates. . . . It is left to the staff of the Open Market Desk of the Federal Reserve Bank of New York to establish guidelines for the growth of reserve aggregates consistent with the Committee's objectives" (p. 9). In this policy environment it is reasonable to suspect that investors would find changes in M1B more informative than changes in the base. However, further research is clearly required before any firm conclusions can be reached.

Second, M1B responds to the demand for credit. Thus announced increases in M1B may provide the market with information about future real activity. In this context an unexpected increase in the money supply leads to an increase in the ex ante real rate. The reserve week effect discussed earlier is a special case of this phenomenon.

The difficulty with this interpretation is that changes in interest rates are too large to be explained by variation in the ex ante real rate. Fama and Gibbons (1982) find that variation in the ex ante real rate accounts for only 20% of the total variance of monthly first differences in interest rates, yet money supply announcements explain over 25% of the variance of daily changes. When the observation interval is shortened to 1 hour Roley (1982) finds that 35% of the variance is attributable to money supply announcements. In addition, the changes in interest rates are too permanent. Is it reasonable for investors to conclude that the ex ante real rate will be higher over the next 30 years on the basis of 1 week's money supply announcement, only to reverse their conclusion the following week? Such behavior seems particularly irrational in the light of the fact that the capital stock, time preferences, and investment opportunities, factors to which Fama and Gibbons attribute variation in the ex ante real rate, are known to evolve slowly over time.

It is almost impossible to reconcile the policy anticipation effect with the behavior of long-term interest rates. As noted earlier, the policy anticipation effect is, in fact, an expected liquidity effect. How is it possible that a 1-week jump in the money supply leads market participants to conclude that monetary restriction will produce permanently higher *real* interest rates over the next 30 years? (The increase in the long-term rate is so large that it cannot be due solely to increases in the short rates; distant forward rates must also rise.) Not only is such a scenario unlikely, but it contradicts a vast literature that has concluded that money is neutral in the long run. It is not surprising, however, that previous studies overlooked this problem and stressed the importance of the policy anticipation effect, because they relied exclusively on Treasury bill data.

There is another problem with the policy anticipation hypothesis. Presumably, the expected liquidity effect would have a smaller impact on interest rates than the actual liquidity effect, because market participants could never be sure that the Fed was going to behave in the predicted manner. At a minimum, the actual liquidity effect should be as apparent in the data as the expected liquidity effect. To test this hypothesis, cross correlations were computed between Wednesday-to-Wednesday changes in interest rates and Wednesday-to-Wednesday changes in monetary aggregates. The time line in figure 1 serves as an aid in illustrating the predicted correlations. Since money supply announcements occur in the second week following the actual change, the liquidity effect should be observed as a negative correlation between announced changes in M1B lagged 2 weeks and changes in interest rates. In the case of the base, the negative correlation should be observed at a lag of 1 week, because the base figures are announced more promptly.

The results reported in tables 8 and 9 reveal that the predicted correlations are not observed. Once again most of the base correlations are small and the few significant coefficients appear to be randomly distributed. The correlations at lag 1 are uniformly insignificant. For the

TABLE 8 **Cross-Correlation Functions for Weekly Monetary Base Changes and Weekly Interest Rate Changes**

	ρ_{-3}	ρ_{-2}	ρ_{-1}	ρ_0	ρ_1	ρ_2	ρ_3	SE
				Full Sample				
DMB vs. *DFF*	−.30	.33	−.20	.03	.11	−.12	.05	.07
DMB vs. *DTB*	−.08	.11	.03	−.05	.12	−.14	.05	.07
DMB vs. *DYB*	−.08	.14	.09	−.07	.11	−.02	−.05	.07
DMB vs. *DN*	−.07	.11	.12	−.04	.09	−.03	−.09	.07
DMB vs. *DB*	−.06	.11	.12	−.01	.05	−.09	−.06	.07
				Post–October 6 Sample				
DMB vs. *DFF*	−.33	.37	−.24	.03	.13	−.14	.02	.10
DMB vs. *DTB*	−.10	.13	.02	−.03	.14	−.18	.05	.10
DMB vs. *DYB*	−.10	.15	.10	−.08	.13	−.05	.07	.10
DMB vs. *DN*	−.09	.13	.14	−.03	.10	−.07	−.12	.10
DMB vs. *DB*	−.07	.13	.15	−.02	.05	−.13	−.06	.10

NOTE.—In tables 8 and 9 interest rate changes are measured from Wednesday's close to the next Wednesday's close. *DMB* represents the actual change in the monetary base.

TABLE 9 **Cross-Correlation Functions for Weekly Money Supply Changes and Weekly Interest Rate Changes**

	ρ_{-3}	ρ_{-2}	ρ_{-1}	ρ_0	ρ_1	ρ_2	ρ_3	SE
				Full Sample				
DM1B vs. *DFF*	.22	−.12	−.02	.23	−.01	.07	−.07	.07
DM1B vs. *DTB*	.09	.05	−.08	.26	.04	.13	.01	.07
DM1B vs. *DYB*	.08	.05	−.03	.34	.05	.01	.01	.07
DM1B vs. *DN*	.09	.03	−.07	.29	.09	.04	−.01	.07
DM1B vs. *DB*	.16	−.02	−.03	.26	.06	.03	−.05	.07
				Post–October 6 Sample				
DM1B vs. *DFF*	.26	−.13	−.03	.28	−.05	.11	−.07	.10
DM1B vs. *DTB*	.08	.08	−.08	.33	.02	.18	.02	.10
DM1B vs. *DYB*	.10	.07	−.05	.40	.04	.06	.06	.10
DM1B vs. *DN*	.12	.04	−.10	.36	.07	.06	−.02	.10
DM1B vs. *DB*	.18	−.01	−.06	.29	.07	.05	−.07	.10

NOTE.—*DM1B* represents the actual change in M1B.

money supply, the predicted negative correlations at lag 2 are not observed, except in the case of Fed funds where the correlation is marginally significant. In conclusion, the data do not reveal the existence of an actual liquidity effect.

The only noticeable pattern in the reported correlations is that changes in M1B are positively correlated with changes in interest rates during the announcement week. Since most of the actual change in M1B is unanticipated, this result is consistent with the previous results. Despite the added noise introduced by the use of weekly data, and despite the fact that actual changes rather than unanticipated changes are used, the money supply announcement effect remains significant.

Using more elaborate tests than cross correlations, Dwyer (1981) and Mishkin (1982) tested the hypothesis that actual, as opposed to announced, innovations in the money supply were negatively correlated with changes in short-term interest rates over the period from 1954 to 1977. Neither author found evidence to support the Keynesian theory. In the case of the long-term market, Mishkin (1981) found no evidence to support the view that increases in the money stock led to a decline in interest rates during the period from 1954 to 1976.

In summary, the data indicate that the impact of the liquidity effect on short and long rates has been small in recent years, if it exists at all. It is difficult, therefore, to accept the policy anticipation hypothesis as an explanation for the reaction of interest rates to money supply announcements.

One interpretation that is consistent with the response of the entire term structure to money supply announcements is that the announcements cause market participants to alter their assessment of the probability that the Fed will "cave in" and abandon its fight against inflation. When the money supply jumps unexpectedly, the probability that the Fed has abandoned its past targets is permanently adjusted upward, and when the money supply falls unexpectedly the probability is permanently adjusted downward. As a result, long-run expected inflation is affected. Though this interpretation is consistent with the data, it is hardly satisfying. It leaves us with no explanation of why market participants react so violently to short-term announcements. It hardly seems rational for an investor to adjust his long-run inflation expectations significantly on the basis of 1 week's announcement.

One possible explanation for this apparently irrational behavior is that the announcement of October 6, 1979, had a far greater influence on investors than has been realized. Before that time the rules under which monetary policy was conducted were relatively stable, though specific policies varied over time. On October 6, market participants suddenly discovered that even the rules of the game were subject to change. As a result they began studying the weekly money supply figures not only with the goal of determining what the current policy was but also with the goal of determining how the rules of the game might be changed. In response to this new source of uncertainty, the volatility of long-run inflation expectations increased dramatically. If this hypothesis is correct, then the volatility of long-term rates may decline over time if the Fed maintains its current operating procedure and the fear of future changes in the rules declines.

VI. Summary and Conclusions

The initial results reported here confirm the findings of prior research. A significant positive correlation is found between innovations in M1B and changes in interest rates. The correlation increased, furthermore, after the Fed's October 6, 1979, announcement of its change in operating procedure. In addition, the response of interest rates to money supply announcements occurred only in the week of the announcement, which is consistent with previous findings on market efficiency.

Further analysis, however, uncovered some vexing problems. Because research by Fama and others implied that innovations in the base may have a larger impact on interest rates than innovations in M1B, both measures were correlated with changes in interest rates. Contrary to prior expectations, innovations in the base are found to be unrelated to changes in interest rates. One explanation for this surprising result is that the Fed sets its targets in terms of M1B, so innovations in M1B may be more informative for predicting futures changes in the base than innovations in the base itself. This explanation, however, needs to be investigated further.

The most interesting, and troublesome, finding is that the entire term structure shifts in response to an unexpected change in the money supply. This result calls into question the policy anticipation, or expected liquidity, effect as an explanation for the reaction of interest rates to money supply announcements. According to the policy anticipation effect, an unexpected increase in the money supply leads money market participants to expect future tightening by the Fed. The anticipated tightening, in turn, causes agents to expect higher interest rates because of the liquidity effect. As a result, agents bid aggressively for current funds and interest rates rise. While the policy anticipation hypothesis provides an adequate explanation for the response of rates on short-term instruments, it cannot be used to explain why the yield on 30-year bonds changes about half as much as the yield on 3-month bills in response to money supply innovations. Either the anticipated period of monetary restraint is expected to be short-lived, in which case it should have little effect on long-term rates, or the anticipated period of monetary restraint is expected to be long-lived, in which case it should reduce expected inflation. In neither case should the long-term rate increase significantly. In addition, no evidence of an actual liquidity effect was found. It is hard to imagine how the expected liquidity effect could be so pronounced if the actual liquidity is so difficult to observe.

Another possible explanation is that announcement of an increase in M1B signals a rise in real activity and agents respond by bidding up the ex ante real rate. The problem with this interpretation is that observed changes in interest rates are too large compared to estimates of the variance of the ex ante real rate. In addition, it is hard to understand why investors would interpret 1 week's money supply number as a signal of a long-run change in real activity.

Of the hypotheses considered, the one most consistent with the dramatic reaction of long-term rates to money supply announcements is that the Fed's stated change in operating procedure had a larger impact on the market than was previously realized. It is hypothesized that in response to the Fed's statement, market participants concluded that the rules under which monetary policy is conduced could no longer be considered constant. As a result, weekly money supply announcements are analyzed with the goal of determining whether another change in the rules is possible. This shift in thinking, in turn, has a markedly destabilizing impact on long-run inflation expectations. In closing, I should stress the tentative nature of this final hypothesis. As is so often the case, further research is clearly required.

References

Barro, R. J. 1977. Unanticipated money growth and unemployment in the United States. *American Economic Review* 67 (March): 101–14.

Barro, R. J. 1978. Unanticipated money, output and the price level in the United States. *Journal of Political Economy* 86 (August): 549–80.

Box, G. E. P., and Jenkins, G. M. 1970. *Time Series Analysis*. San Francisco: Holden-Day.

Conrad, W. E. 1978. Initial treasury bill market response to money stock announcements. Working Paper. New York: Federal Reserve Bank.

Cornell, B. 1979. Money supply announcements and interest rates. *Journal of Money, Credit and Banking* 11 (February): 80–87.

Dornbusch, R. 1976. Expectations and exchange rate dynamics. *Journal of Political Economy* 84 (December): 1161–76.

Dwyer, G. P. 1981. Is variation of the expected real interest rate unpredictable? *Journal of Monetary Economics* 8 (January): 59–84.

Fama, E. F. 1970. Efficient capital markets: a review of the theory and empirical work. *Journal of Finance* 25 (May): 383–417.

Fama, E. F. 1975. Short-term interest rates as predictors of inflation. *American Economic Review* 65 (June): 269–82.

Fama, E. F. 1982. Inflation, output, and money. *Journal of Business* 55 (April): 201–32.

Fama, E. F., and Gibbons, M. R. 1982. Inflation, real returns and capital investment. *Journal of Monetary Economics* (in press).

Gibbons, M. R., and Hess, P. 1981. Day of the week effects and asset returns. *Journal of Business* 54 (October): 579–96.

Gilbert, R. A., and Trebing, M. E. 1981. The FOMC in 1980: a year of reserve targeting. *Federal Reserve Bank of St. Louis Monthly Review* 63 (August): 2–16.

Grossman, J. 1981. The rationality of money supply expectations and the short-run response of interest rates to monetary surprises. *Journal of Money, Credit and Banking* 13 (November): 409–24.

Hess, P. J., and Bicksler, J. L. 1975. Capital asset prices versus time series models as predictors of inflation: the expected real rate of interest and market efficiency. *Journal of Financial Economics* 2 (December): 341–60.

Mishkin, F. S. 1981. Monetary policy and long-term interest rates: an efficient markets approach. *Journal of Monetary Economics* 7 (January): 29–55.

Mishkin, F. S. 1982. Monetary policy and short-term interest rates: an efficient markets rational expectations approach. *Journal of Finance* (in press).

Nelson, C. R. 1973. *Applied Time Series Analysis*. San Francisco: Holden-Day.

Nelson, C. R., and Schwert, G. W. 1977. Short-term interest rates as predictors of inflation: on testing the hypothesis that the real rate of interest is constant. *American Economic Review* 67 (June): 478–86.

Roley, V. 1982. The response of short-term interest rates to weekly money announcements. Working Paper. Kansas City, Mo.: Federal Reserve Bank.

Shiller, R. J. 1979. The volatility of long-term interest rates and expectations models of the term structure. *Journal of Political Economy* 87 (December): 1190–1219.

Sivesind, C. M. 1978. Efficient markets and the reaction of securities markets to the weekly M1 announcements. Working Paper. New York: Federal Reserve Bank of New York.

Urich, T. J. 1979. The information content of weekly money supply announcements. Working Paper. New York: New York University.

Urich, T. J., and Wachtel, P. 1981. Market responses to weekly money supply announcements in the 1970s. *Journal of Finance* 36 (December): 1063–72.