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I. INTRODUCTION

The reaction of financial markets to the Federal Reserve's weekly money supply announcement has been intensively investigated. Most studies have assumed that markets are efficient and thus only surprises in the money stock announcement influence interest rates.[1/] This assumption has been based on empirical findings that the anticipated component of the announcement does not affect interest rates.[2/] The anticipated announcement appears to be insignificant both before and after the October 1979 change in Federal Reserve operating procedures as well as across the February 1980 change in the day of the announcement from Thursday to Friday.

Recently, however, several authors [Roley (1983); Belongia and Kolb (1984); Gavin and Karamouzis (1984)] have reported a significant effect on interest rates associated with the expected change in money. The significance of anticipated money announcements is in conflict with predictions based on the efficient markets hypothesis, which maintains that current expectations will be fully incorporated in current values of interest rates. Thus, expectations should have no significant impact on subsequent interest rate movements. Although Roley (1983) contends that the efficient markets hypothesis still holds because the survey of expectations does not fully reflect all information available prior to the money announcement, Hein (1985) has argued that Roley's method of revising expectations is incorrect. When Hein revises the expectations by an alternate method, expected money is again significant.[3/] Overall, these recent results suggest potential problems with the literature on the effects of weekly money announcements.

Our intention in this paper is to show that previous studies of money announcement data have omitted significant variables with important implications for the efficient market hypothesis. In addition, some previous studies have used a measure of the dependent variable that is subject to unnecessary measurement error. As a consequence of these difficulties, incorrect assertions about the efficient markets hypothesis have been made. A form of the model and data that avoids--or at least minimizes--the effects of these errors is applied to the same sample periods used in earlier studies. We find, in each case, that the procedures used here allow us to conclude that the expected money announcement and other fully anticipated events influence interest rates, in contrast to the criteria for market efficiency.

II. EFFICIENT MARKETS: TESTING THE EFFECT OF MONEY SUPPLY ANNOUNCEMENTS

The standard model used to examine to the effect of weekly money announcements is:

(1) $\Delta TB_t = \alpha + \beta_1 U\Delta M_t + \beta_2 E\Delta M_t + \varepsilon_t$

where ΔTB is the change in the three-month Treasury bill rate, $U\Delta M$ is the unexpected change in the money stock, $E\Delta M$ is the expected change in the money stock and ε is an error term with the classical properties. The t subscript denotes a particular weekly announcement date. Under the efficient markets hypothesis, we expect $\beta_1 \neq 0$ and $\beta_2 = 0$. This form of the model and the implied tests are derived elsewhere [e.g., Urich (1982)] and will not be discussed here.

While there are many possible difficulties in estimating equation (1), two considerations seem to be particularly crucial. One is the measurement of interest rate changes and the other is the treatment of expected money.

Measuring Changes in Interest Rates

As Cornell (1979) and others have noted, an accurate assessment of the impact of money surprises depends on how well the money announcement is isolated from other events. Since agents receive a continuous flow of information, measuring the change in interest rates across a period of one day or more necessarily confuses the announcement effect with the reaction to other new information. Econometrically, this may be viewed as an error-in-variables problem.

Ideally, changes in interest rates would be measured from the moment just prior to the announcement to the rate quoted on the first trade following the announcement. As a practical matter, the most narrow window through which interest rate changes have been measured is the interval between the 3:30 p.m. (EST) close of the New York bond market and a 5:00 p.m. Telerate measure of rates quoted on trades that followed the announcement.

While these data exist, a surprising number of studies have chosen to measure the change in interest rates from the close of trading at 3:30 p.m. on Friday to the close of trading at 3:30 p.m. on the following Monday. Using data from the longer interval adds more "noise" into the measurement of the dependent variable. This data change introduces the classical error-in-variables problem into the dependent variable. The estimated coefficients on $U\Delta M$ and $E\Delta M$ will not be biased as long as the errors introduced by the longer measurement interval are independent of the announced and expected money stocks. The standard errors, however, will be increased by the additional noise in the data thus making it more difficult to reject a null hypothesis of $\alpha = 0$, $\beta_1 = 0$, or $\beta_2 = 0$. Clearly this change by itself is not a problem in those studies that focus on unexpected money and find its estimated coefficient is significant. It may be a considerable problem, however, in those studies which conclude that expected money is insignificant.[4/] That is, failure to use the 3.30-5:00 p.m. change in interest rates biases a test of the efficient markets hypothesis against rejecting the null hypothesis that markets are efficient.

In addition to the increased measurement error introduced by the longer measurement period of the dependent variable, the Friday close to Monday close procedure potentially incorporates a "weekend" effect as well as an announcement effect. Equation (1) is designed exclusively to measure the announcement effect associated with the release of information on the weekly money stock. In contrast, there is evidence suggesting that yields on financial assets may change over the weekend for reasons independent of the money announcement.[5/] Thus, estimates of equation (1) based on Friday close to Monday close may be capturing the weekend effect rather than any effect associated with the money announcement.

Mis-specifications of the Estimating Equation

A second potential problem with some previous estimates of equation (1) is the treatment of expected money. While $E\Delta M$ has been represented by both the Money Market Services, Inc. survey responses and by time series estimates of market expectations, with no qualitative change in results, the efficient markets test clearly implies that $E\Delta M$ be included in the model. Studies that have deleted this variable and that have estimated (1) with only money surprises on the right hand side have simply assumed the efficient markets hypothesis holds with respect to the money announcement. If the efficient markets hypothesis holds and if financial market participants have rational expectations, then estimating equation (1) with the constraint $\beta_2 = 0$ is correct. In contrast, if the efficient markets hypothesis does not hold, then imposing that constraint is clearly inappropriate. In addition, if the hypothesis of rational expectations is also dropped, E∆M and U∆M may be correlated. In that case, the estimated coefficient on U∆M would also be biased. The point being made here is simply that previous studies have imposed constraints on equation (1) that some evidence suggests may not be justified. Moreover, the constraints can be readily tested.

III. SENSITIVITY OF RESULTS TO SPECIFICATION CHANGES

The foregoing discussion of measurement and specification issues in testing the efficient markets hypothesis noted two fundamental changes that would bring the results of earlier studies closer to satisfying the requirements of a true test of the efficient markets hypothesis. Table 1 lists a sample of studies that have examined reactions of the three-month Treasury bill rate to the money announcement on post-1979 data. As the table shows, these studies have measured interest rate changes across weekends and/or have omitted expected money from the test. In fact, of the nine studies cited, only two, Cornell (1983b) and Roley (1982), fail to do both. While these criticisms apply equally well to most studies of data prior to October 1979, the results apparently are unaffected by the measurement or specification errors discussed (see, e.g., Belongia and Kolb).

The sensitivity of these results to the precise measure of interest rate changes and to the inclusion of EΔM in the model are reported in Table 2. Equation (1) was estimated using the 3:30-5:00 p.m. changes in interest rates over the same sample periods used by the studies surveyed in Table 1. Each of these studies reported or assumed market efficiency--in the sense that only UΔM had a significant effect on the three-month Treasury bill rate. In contrast, the results in Table 2 indicate that this conclusion is reversed in each case when interest rate changes are measured appropriately and when the estimating equation includes expected and unexpected money changes.

IV. POSSIBLE EXPLANATIONS FOR SIGNIFICANT EFFECTS FROM EXPECTED MONEY

The results in Table 2 indicate that expected changes in money have significant effects for each of the nine sample periods. It is possible, however, that these results are subject to other econometric problems that may invalidate our finding of significant effects from fully anticipated events. Potential problems include the use of biased expectations data and the omission of other market information that becomes available between the time of the expectations survey and the money announcement. We turn now to these issues.

Bias in the MMS Survey of Expectations

The efficient markets hypothesis is based, in part, on the rationality of agents and their efficient use of information. If expectations were found to be biased, agents clearly would not be using information efficiently and one of the conditions for an efficient market would be violated prior to any specific testing for the effects of anticipated and unanticipated changes in the information set. It is essential, therefore, that the expectations data used to estimate equation (1) are unbiased.

It is possible to test this proposition by estimating:

(2) $\Delta M_t = \gamma + \beta \; E\Delta M_t + \varepsilon_t$

where ΔM is the actual, first-announced change in M1 and $E\Delta M$ is the expected change as represented by the MMS, Inc. survey median. Expectations may be called unbiased if it is not possible to reject the joint hypothesis $\gamma = 0$ and $\beta = 1$.

The results in Table 3 indicate that it is not possible to reject the null hypothesis for unbiasedness at the 5 percent significance level for any of the sample periods considered. The F-statistics for the periods used by Cornell (1982 and 1983b) and Roley (1982) are the closest to being significant, entering at the 0.09 and 0.10 significance levels, respectively. On the basis of these results we conclude that the significance of expected money reported in Table 2 is not a result of using a biased measure of expectations.

Impact of Additional Information

As Roley (1983) and others have noted, the MMS, Inc. survey is compiled as of Tuesday but (for most of the listed sample periods) the money announcement does not occur until Friday. Over this three day interval, agents surely gather additional information and revise their expectations accordingly. In this case, measurement error is present and is associated with the independent variables $U\Delta M$ and $E\Delta M$.[6/]

The efficient markets hypothesis predicts that any new information should quickly be reflected in interest rates. Thus, information that becomes available to the market between the time expectations are surveyed and the time the money announcement is made should be reflected in the pre-announcement interest rate. The impact of this additional information on the three-month Treasury bill rate should be incorporated in the change in that rate from the 3:30 p.m. close on Tuesday to the 3:30 p.m. close on the money announcement day. Calling this change $\Delta TB'$, we can estimate:

$$(3) \quad \Delta TB = \alpha + \beta_1 \, U\Delta M_t + \beta_2 \, E\Delta M_t + \beta_3 \, \Delta TB' + \varepsilon_t$$

where the 3:30-5:00 p.m. change in the Treasury bill rate on the announcement day now depends on unexpected and expected money and the new market information assembled after the survey of expectations was conducted. The efficient markets hypothesis now implies $\beta_1 \neq 0$ and $\beta_2 = \beta_3 = 0$.

Estimating (3) for the sample periods of earlier studies produces the results shown in Table 4. These results uniformly support the earlier conclusion: for the samples studied, fully anticipated events significantly affect changes in interest rates and the efficient markets hypothesis is rejected. In each of the nine cases, both expected changes in money and the Tuesday-to-announcement day change in interest rates are significant.

CONCLUSIONS

Previous studies have generally assumed or concluded that only the unanticipated component of the money announcement influenced interest rates. We demonstrate that this support for the efficient markets hypothesis is based on one or more econometric errors that bias statistical tests against rejecting the null hypothesis that anticipated events matter. When the interest rate change is appropriately measured and the test is properly specified, both the expected and unexpected components of the money announcement are significant and the efficient markets hypothesis is rejected. This result provides macroeconomic support for the basically microeconomic finding of Elton, Gruber, and Rentzler (1984) that the Treasury bill market may not be efficient. Furthermore, we are able to demonstrate that the results presented here are not due to biased expectations or to additional information becoming available between the time of the survey and the time of the money announcement. Why expected money is significant remains a topic for further research with differential transactions costs one potential explanation.

FOOTNOTES

1/ For example, see Roley and Troll (1983), Cornell (1982), Cornell (1983a), Shiller et al. (1983), Hardouvelis (1984), and Roley (1982).

2/ For example, see Grossman (1981), Urich (1982), Roley and Walsh (1984), and Cornell (1983b).

3/ Roley's argument is based on the survey of expectations being conducted on Tuesday while additional information becomes available between the time of the survey and the time of the announcement. Gavin and Karamouzis (1984) also suggest that the survey expectation may be an imperfect measure of actual market expectations. While more information may be available immediately prior to the announcement than was available on Tuesday when the survey was conducted, there is no evidence to suggest that the Tuesday survey is not an accurate indicator of the market's expectations on Tuesday about the Thursday announcement.

4/ Belongia and Kolb (1984) present evidence on this point.

5/ For example, see Gibbons and Hess (1981). During their period of analysis the money stock announcement was made on Thursday. Thus, their results do not mix the announcement and the weekend effects.

6/ In this case, $U\Delta M$ is actually a combination of expected and unexpected money changes. If the efficient markets hypothesis holds (so $\beta_1 > 0$ and $\beta_2 = 0$), then $\hat{\beta}_1$ will be a linear combination of the true impacts of the unanticipated and anticipated money announcements. Thus, $\hat{\beta}_1$ would be biased toward zero. $\hat{\beta}_2$ would be the coefficient on the imperfect measure of expected money and would still equal zero. In contrast, if the survey measure were "too good" a measure of market expectations, that is, if market participants on average had less information or less accurate expectations than the survey median forecast, then the situation is reversed. $E\Delta M$ would represent a combination of expected and unexpected terms; $\hat{\beta}_2$ would be biased away from zero; and $\hat{\beta}_1$ would be unbiased.

Table 1
Measurement or Specification Errors in Post-1979 Studies of the Weekly Money Announcement

	3:30 Friday-3:30 Monday Change in Interest Rates	Expected Money Omitted from Test
Cornell (1982)	Yes	Yes
Cornell (1983a)	Yes	Yes
Cornell (1983b)	Yes	No
Roley and Troll	Yes	Yes
Roley (1982)	No	Yes
Shiller, et al.	Yes	Yes
Hardouvelis	Yes	Yes
Judd	Yes	Yes
Urich and Wachtel	Yes	Yes

Table 2
Sensitivity of Weekly Money Studies to Measurement and Specification Error

Model: $\Delta TB_t = \alpha + \beta_1 \, U\Delta M_t + \beta_2 \, E\Delta M_t + \varepsilon_t$

Author	Sample	α	$\hat{\beta}_1$	$\hat{\beta}_2$	$\bar{R}^2$	D-W
Cornell (1982)	10/11/79-12/12/81	-0.014	0.052	-0.037	0.32	1.93
		(0.81)	(7.21)	(2.27)		
Cornell (1983a)	10/11/79-8/28/81	-0.016	0.052	-0.042	0.31	1.94
		(0.81)	(6.56)	(2.30)		
Cornell (1983b)	10/11/79-12/18/81	-0.012	0.052	-0.039	0.32	1.92
		(0.70)	(7.28)	(2.38)		
Roley and Troll	10/11/79-10/15/82	-0.011	0.053	-0.024	0.30	1.91
		(0.73)	(8.02)	(2.29)		
Roley (1982)	2/8/80-11/20/81	-0.015	0.053	-0.039	0.30	1.87
		(0.72)	(6.36)	(2.04)		
Shiller, et al.	2/15/80-2/1/83	-0.010	0.056	-0.022	0.31	1.91
		(0.61)	(8.16)	(2.17)		
Hardouvelis	2/15/80-11/16/82	-0.010	0.058	-0.023	0.32	1.90
		(0.61)	(8.14)	(2.14)		
Judd	10/11/79-10/3/82	-0.009	0.052	-0.027	0.30	1.87
		(0.57)	(7.96)	(2.42)		
Urich and Wachtel	10/11/79-7/30/82	-0.010	0.052	-0.027	0.30	1.80
		(0.64)	(7.88)	(2.32)		

Absolute values of t-statistics in parenthesis

Table 3
Tests for Bias in MMS, Inc. Survey of Expectations

Model: $\Delta M = \alpha + \beta_1 E\Delta M_t + \varepsilon_t$

Author	$\hat{\alpha}$	$\hat{\beta}_1$	F	$\bar{R}^2$	D-W
Cornell (1982)	0.136 (0.59)	1.402 (6.70)	2.50	0.28	1.82
Cornell (1983a)	0.134 (0.52)	1.356 (5.87)	1.64	0.25	1.83
Cornell (1983b)	0.153 (0.67)	1.391 (6.69)	2.48	0.28	1.82
Roley and Troll	0.235 (1.27)	1.153 (9.12)	1.89	0.34	1.92
Roley (1982)	0.066 (0.245)	1.466 (6.24)	2.38	0.30	1.62
Shiller, et al.	0.272 (1.49)	1.132 (9.42)	2.11	0.36	1.98
Hardouvelis	0.246 (1.29)	1.138 (8.97)	1.76	0.36	1.93
Judd	0.247 (1.32)	1.177 (8.60)	2.07	0.32	1.90
Urich and Wachtel	0.217 (1.10)	1.223 (8.29)	2.10	0.32	1.88

Absolute values of t-statistics in parenthesis

F statistic applies to the joint hypothesis $\alpha = 0$ and $\beta_1 = 1$.

Table 4
Tests for the Effects of New Information After the Expectations Survey

Model: $\Delta TB = \alpha + \beta_1 U\Delta M_t + \beta_2 E\Delta M_t + \beta_3 \Delta TB' + \varepsilon_t$

Author	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\bar{R}^2$	D-W
Cornell (1982)	-0.027 (1.45)	0.058 (7.64)	-0.047 (2.75)	-0.090 (2.46)	0.35	1.73
Cornell (1983a)	-0.029 (1.42)	0.057 (7.01)	-0.053 (2.76)	-0.091 (2.22)	0.35	1.74
Cornell (1983b)	-0.024 (1.35)	0.058 (7.72)	-0.048 (2.86)	-0.090 (2.46)	0.36	1.72
Roley and Troll	-0.023 (1.44)	0.058 (8.37)	-0.027 (2.52)	-0.083 (2.44)	0.32	1.77
Roley (1982)	-0.025 (1.15)	0.058 (6.80)	-0.049 (2.49)	-0.097 (2.37)	0.34	1.61
Shiller, et al.	-0.019 (1.17)	0.062 (8.66)	-0.024 (2.39)	-0.089 (2.63)	0.34	1.80
Hardouvelis	-0.020 (1.15)	0.065 (8.65)	-0.026 (2.43)	-0.092 (2.62)	0.36	1.78
Judd	-0.021 (1.33)	0.058 (8.37)	-0.032 (2.76)	-0.088 (2.58)	0.33	1.73
Urich and Wachtel	-0.022 (1.36)	0.057 (8.26)	-0.032 (2.67)	-0.087 (2.49)	0.33	1.63

Absolute values of t-statistics in parenthesis

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