On the Importance of Being Expected: Insights to the Weekly Money Puzzle

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I. INTRODUCTION

The reaction of short-term interest rates to the Federal Reserve's weekly announcement of the money stock has stimulated substantial research. Previous studies have examined the impacts of the money stock announcements on a variety of short-term interest rates, stock market indexes and exchange rates.[1/] Most prior studies have considered only the effect of unanticipated money stock announcements on financial market variables.[2/] This focus was derived from an efficient markets hypothesis which predicts that only the announcement "surprise" will alter financial market variables because the effect of the expected announcement is already incorporated in market prices. Early studies generally supported the contention that only unanticipated changes were significant.

Recently, however, several authors have found expected money changes also are significant.[3/] One alternative explanation for the statistical significance of expected money is that a

simplistic notion of informationally efficient markets implied in money studies but may be an inappropriate assumption. We present a more general model of impact of the money announcement where actual, expected and unexpected money stocks all may influence financial market variables. This more general model is then estimated and some implications are drawn from the results both for the efficient markets hypothesis and for the process of interest rate determination.

II. THE MODEL

Any model based on the efficient markets hypothesis must begin with the assumption that financial market variables, such as short-term interest rates, incorporate all information currently available to the market, including expectations of future variables; future policy decisions are one argument in this set. Furthermore, financial market variables also may be influenced ex post by past actual values of variables, such as the money stock or lagged dependent variables to the extent that monetary policy has real effects that are felt gradually over time. Algebraically, this hypothesis can be formulated for, say, a short-term nominal interest rate, as:

$$(1)\quad i_t = f(M_{t-1}, M_{t-2}, \cdots, i_{t-1}, i_{t-2}, \cdots, I_t)$$

where i_t is a short-term nominal interest rate at time t, I_t is the information set available at time t, and M is the actual money stock. The time interval used throughout is very short, no more than one day and preferably shorter. The use of very short time intervals is endemic in the money stock announcement literature. The objective is to obtain a time interval short enough that (a) a money announcement is made, (b) financial markets react to the announcement and (c) nothing else happens during the period.

As equation (1) is written, the lagged money stock terms capture whatever real effects monetary policy has, e.g., altering the actual supply of credit, while the lagged interest rate terms measure the inertia in the responses. These terms may also appear in the information set. Thus, it is instructive to decompose the information set. This is done in equation (2) where it is also assumed, for analytical simplicity, that the function is linear. Hence:

$$(2)\quad i_t = \alpha_0 + \sum_{j=1}^{J} \alpha_j M_{t-j} + \sum_{j=1}^{J} \beta_j i_{t-j} + \gamma_0 \tilde{I}_t$$

$$+ \sum_{j=1}^{L} \gamma_j M^a_{t-jk_1-k_2} + \sum_{j=1}^{K} \phi_j \, {}_{t-k_3}M^e_{t+jk_1} + \varepsilon_t$$

where $\tilde{I}$ = the available information set excluding M^a, M^e and i,

M^a = previously announced money stock (data revisions are ignored), and

M^e = expected future money announcements.

The money stock announcement is made once per week when there are k_1 periods during the week and the announcement was made k_2 periods ago. The next announcement, which is expected to be M^e, will then be announced $k_2 - k_1$ periods in the future. We assume that expectations about the money stock are formed at some fixed time during the week occurring k_3 periods ago. We further assume that while these expectations may be revised during the week, the only information that is used to revise them is the new information contained in interest rates in periods since expectations were formed, i.e., i_{t-1}, i_{t-2}, ... , i_{t-k_3}. The efficient markets hypothesis predicts that new information should be quickly embodied in financial market variables. Thus, any new information that would alter M^e should also be reflected in the interest rate terms, and no information is lost by not updating M^e continuously. These last two assumptions are made solely to facilitate the development of a testable model given that data on expectations of the money

announcement, in recent time periods, are available but once per week. Note that with this interpretation the β_j ($j \neq 0$) parameters are reduced-form coefficients rather than structural coefficients.

The step from equation (1) to equation (2) also assumes that the function itself does not change over time. Financial market participants are assumed to respond in the same way each week as well as within each week. The latter assumption, in particular, may not be entirely accurate depending on the precise institutional arrangements of the particular market.[4/] To avoid those types of effects, we only compare the function at the same time interval from one week to the next. Thus, stability is assumed on a week-to-week basis.

Differencing equation (2), assuming that the function itself does not change from t to t+1 and further assuming that the interval from t to t+1 includes neither the money stock announcement nor the expectations formation yields:

$$(3) \quad \Delta i_t \equiv i_{t+1} - i_t = \sum_{j=1}^{J} a_j \Delta M_{t-j} + \sum_{j=1}^{J} \beta_j \Delta i_{t-j} + \beta_0 (\tilde{I}_{t+1} - \tilde{I}_t) + (\varepsilon_{t+1} - \varepsilon_t) .$$

Under the assumption of efficient markets, lagged changes in the interest rate should convey no

information about the current change. Any systematic relation between Δi_t and Δi_{t-j} should be eliminated rapidly through arbitrage.

We further assume, following Cornell (1979), that information apart from the money announcement is randomly distributed over the week. Under these assumptions, equation (3) can be simplified to:

$$(4) \quad \Delta i_t = \sum_{j=1}^{J} \alpha_j \Delta M_{t-j} + \eta_t .$$

Equations of this form have been estimated by Brown and Santoni (1983) and Melvin (1983) using monthly data to measure the net impact of the liquidity and Fisher effects.

How is the simplification of equation (3) to (4) altered when the period t+1 is the money announcement period? Differencing equation (2) now yields:

$$\begin{aligned}(5) \quad \Delta i_t = & \sum_{j=1}^{J} \alpha_j \Delta M_{t-j} + \sum_{j=1}^{J} \beta_j \Delta i_{t-j} + \beta_0 (\tilde{I}_{t+1} - \tilde{I}_t) \\ & + \sum_{j=1}^{L} (\gamma_{j+1} - \gamma_j) M^a_{t-jk_1-k_2} + (\gamma_1 M^a_{t+1} - \psi_{1\ t-k_3} M^e_{t+1}) \\ & + \sum_{j=1}^{K} (\psi_{j\ t+1-k_3} M^e_{t+jP_2} - \psi_{j+1\ t-k_3} M^e_{t+jk_2}) \\ & + \varepsilon_{t+1} - \varepsilon_t .\end{aligned}$$

Again assuming that lagged interest rate changes convey no information about current interest rate changes and that information on variables other than money is randomly distributed allows us to simplify equation (5) to:

$$(6)\quad \Delta i_t = \sum_{j=1}^{J} \alpha_j \Delta M_{t-j} + \sum_{j=1}^{L} (\gamma_{j+1} - \gamma_j) M^a_{t-jk_1-k_2} + (\gamma_1 M^a_{t+1} - \psi_1 \; {}_{t-k_3}M^e_{t+1}) + \sum_{j=1}^{K} (\psi_j \; {}_{t+1-k_3}M^e_{t+jk_2} - \psi_{j+1} \; {}_{t-k_3}M^e_{t+jk_2}) + \eta_t .$$

This is a more general expression for the impact of money announcements than employed in previous studies. In particular, for reasons explained in detail below, expectations have a channel of influence on financial market variables even with the assumption of efficient markets.

One additional assumption inherent in equation (6) should be mentioned at this point. Expected money was allowed to change but once per week. It is conceptually appealing to assume that expectations concerning future money stock announcements change in that period when the money stock is announced. We have written equation (6) as though expectations change then. Data availability, however, will preclude that as a viable option in the

estimation section. Thus, the reader may wish to think intuitively of there being two revisions, one when the money announcement is made and one later in the week as additional interest rate data becomes available.

Equation (6) should be contrasted with the specification traditionally used to estimate the impact of money announcements on financial market variables:

$$(7) \quad \Delta i_t = \rho_0 + \rho_1 (M_t^a - {}_{t-k_3}M_t^e) + \mu_t .$$

Clearly equation (7) imposes significant restrictions on equation (6). We turn next to the implications of those restrictions.

III. CONSEQUENCES OF IMPLIED RESTRICTIONS IN STUDIES OF THE MONEY ANNOUNCEMENT

Let us first adopt a more standard notation for dating the variables. Generally, previous studies have considered changes, say, in interest rates, over a narrow interval that spans the money stock announcement and have ignored interest rate changes at other times during the week. Following the same convention, the time subscript t can be redefined to refer to a one week interval without introducing any ambiguity where Δi_t refers to,

say, the change in the interest rate from 3:30 p.m. to 5:00 p.m. (E.S.T.) on the day of the money announcement. (The announcement itself is generally made at 4:10 p.m. E.S.T.) Then equations (6) and (7) become:

$$(6') \quad \Delta i_t = \sum_{j=1}^{S} \alpha_j \Delta M_{t-j} + \sum_{j=1}^{L} (\gamma_{j+1} - \gamma_j) M^a_{t-j}$$
$$+ (\gamma_1 M^a_t - \psi_{1\ t-1} M^e_t)$$
$$+ \sum_{j=1}^{K} (\psi_{j\ t} M^e_{t+j} - \psi_{j\ t-1} M^e_{t+j}) + \eta_t$$

and

$$(7') \quad \Delta i_t = \rho_0 + \rho_1 (M^a_t - {}_{t-1} M^e_t) + \mu_t .$$

Equation (7') imposes four restrictions on equation (6'):

(a) $\sum_{j=1}^{S} \alpha_j \Delta M_{t-j} = 0$

(b) $\sum_{j=1}^{L} (\gamma_{j+1} - \gamma_j) M^a_{t-j} = 0$

(c) $\gamma_1 = \psi_1 = \rho_1$ and

(d) $\sum_{j=1}^{K} (\psi_{j\ t} M^e_{t+j} - \psi_{j\ t-1} M^e_{t+j}) = 0$

We discuss the implications of each of these restrictions in turn.

Restriction (a) implies that previous actual changes in the money supply have no aggregate impact on the change in interest rates from 3:30 to 5:00 p.m. on the announcement day. Given that Brown and Santoni (1983) found estimates of α_j from equation (4) of less than 15 basis points per month, it would seem hard to argue from a pragmatic perspective that restriction (a) does not hold. On an average daily basis, the α_j coefficients would be expected to be less than .8 basis points, an amount likely smaller than the transactions cost of buying or selling any short-term bill.[5/]

Constraint (b) can be interpreted as restricting the interpretation of previous money announcements. Specifically, this week's money announcement is assumed not to alter the aggregate interpretation of previous announcements.[6/] The money stock announcement provides information to financial market participants about the probable future course of monetary policy. While any one week's announcement may be heavily discounted given the significant random noise in the announcement series, it may at the margin alter the perceived informational content of prior announcements. For

example, four consecutive larger than expected increases may be perceived to reveal changes in policy that any single week's change would not. If the fourth increase (or the third or the second) leads to a reevaluation of previous increases, restriction (b) does not hold.[7/]

Constraint (c), the simplest of the four, also may be the most important. The value of γ_1 versus ψ_1 is an indication of the extent to which financial market participants are forward looking as opposed to backward looking. The conventional assumption that $\gamma_1 = \psi_1$ implies that financial market participants place equal weights on the announced money stock and the expected money stock as determinants of the current interest rate. In contrast, if financial market participants are primarily forward looking, then $\psi_1 > \gamma_1$. The restriction $\gamma_1 = \psi_1$ assumes interest rates respond symmetrically to announced and expected money. While this may be true, it certainly is not a necessary condition for the efficient markets hypothesis to hold.

The last constraint is very similar in interpretation to restriction (b). Restriction (b) implies that the money announcement may change the interpretation of previous money announcements.

Restriction (d) implies that the money announcement may alter expectations of future changes in the money stock. Unlike the other restrictions, (d) cannot be tested with the available survey data. Survey data are only available on ${}_tM^e_{t+1}$ and not on ${}_tM^e_{t+2}$.

Unlike the other constraints, however, this last restriction has often been mentioned in the money announcements literature. Specifically, the expected liquidity effect and the inflation premium effect are predicated on alternate assumptions about the response of future policy to a current surprise. With the assumption that the current money announcement conveys information about expectations of future changes in the money stock, equation (6') can be rewritten as:

$$(8)\quad \Delta i_t = \sum_{j=1}^{S} \alpha_j \Delta M_{t-j} + \sum_{j=1}^{L} (\gamma_{j+1} - \gamma_j) M^a_{t-j}$$

$$+ (\gamma_1 - \psi_1) M^e_{t-1,t} + \gamma_1' M^u_t + \eta_t$$

where M^u_t is the surprise component of the money announcement and γ_1' now represents a reduced form parameter including the coefficient γ_1 plus the impact on the interest rate of the revision in the future expected money stocks.

IV. ESTIMATION

For estimation, equation (8) was modified by combining the M and M^a terms. Ignoring data revisions, the money announcements refer to the stock of money. The estimated equation is then:

$$(9) \quad \Delta i_t = \sum_{j=1}^{S} \alpha_j' \Delta M_{t-j} + (\gamma_1 - \psi_1)\ {}_{t-1}M_t^e + \gamma_1' M_t^u + \eta_t$$

where $\alpha_1' = \alpha_1$ and

$$\alpha_j' = \alpha_j + (\gamma_{j+1} - \gamma_1) \text{ for } j > 1 .$$

Thus, the coefficients on lagged money changes generally capture both the liquidity effect and the impact of revised interpretations of previous money announcements.

The dependent variable, Δi, is the 3:30 p.m. to 5:00 p.m. change in the three-month Treasury bill rate on the day of the money announcement. The lagged changes in the actual money stock, ΔM_{t-j}, are the changes in M1, as announced, with revisions incorporated to the series if the revisions were known to market participants prior to the announcement. M^e, the expected level of M1, is the actual level in week t-1 plus the expected change in the level as measured by the Money Market Services,

Inc. survey median. M^u is then the difference between the actual and expected level of M1. Equation (9) is also estimated with and without a measure of the change in the T-bill rate between 3:30 p.m. on Tuesday (the day of the MMS, Inc. survey) and 3:30 p.m. on the money announcement day. This variable, Δi (T-Th), is included to capture new information acquired by the market after the survey is conducted.[8/]

Equation (9) is estimated over three sample periods to isolate changes in the market's response to information under different policy regimes. The first period runs from 2/8/80 to 10/8/82. This interval begins when the money announcement was changed from Thursday to Friday and includes only the period when the Fed's announced policy was one of targeting nonborrowed reserves. The second interval runs from 10/8/82 to 11/14/83, which begins after the Fed announced its de-emphasis of M1 as an aggregate target and runs to the end of the sample. The entire 2/8/80 - 11/14/83 sample also is examined but, in view of the regime change(s), the results must be interpreted with caution.

V. RESULTS

The estimates of equation (9) over each of the three samples are presented in table 1. The

columns headed (A) omit the Tuesday through Thursday change in interest rates, while the columns headed (B) include this additional variable. The lag lengths for ΔM_{t-j} in the different models were chosen in pretest estimation by the FPE criterion.[9/]

Looking at the models as a group reveals quite clearly that the period after M1 was de-emphasized in October 1982 marks a distinct shift in interest rate response at the time of the money announcement. In sharp contrast to the prior period, past changes in M1 were not chosen for inclusion in the model and the Tuesday through Thursday change in interest rates was not significant. More on the interpretation of this period's results will be said below.

The other general conclusion about these results is that there is clear evidence that fully anticipated events are important, although the most significant variable in each equation continues to be the surprise component of the money announcement. Lagged changes in the money stock have a significant effect on interest rate changes at the time of the current week's money announcement. Moreover, changes in interest rates between the time of the survey and the money announcement also influence post-announcement interest rates. The significance

of these variables clearly contradicts simple versions of informational efficiency which argue that current interest rates are unaffected by existing available information.

Rather than rejecting the efficient markets hypothesis per se, the significance of known events offers evidence that at least some of the restrictions on equation (6') are rejected by the data. That is, traditional tests of informational efficiency with regard to the money announcement have considered each announcement as an independent event. The results in table 1 merely advance the decision apparatus of market agents to include the notion that the cumulative impact of several announcements may be viewed as offering indications of future policy actions.

Based on equation (9), it is not possible to identify precisely which of the constraints are not satisfied. A limit may be placed, however, on the restrictions which are not satisfied. The significance of lagged money changes implies that constraint (a) and/or constraint (b) do not hold. Given that previous studies that have directly estimated the liquidity effect have found an anemic influence, it would seem plausible that constraint (b) is not satisfied. Thus, expected money changes

are reinterpreted in light of current money changes. The current money announcement aids in interpreting whether previously-announced values were permanent or transitory changes. This interpretation is also supported by the insignificance (at the 5 percent level) of the only coefficient which exclusively measures the liquidity effect, α_1'.

Constraint (c) on the symmetry restrictions cannot be rejected at the 5 percent significance level in any period (although at the 10 percent level it can be rejected for the 10/8/82 - 11/14/83 period). This result suggests that financial market participants place approximately equal weights on the announced versus the expected money stock as determinants of the current interest weight.

Constraint (d), in contrast, cannot be directly tested. Circumstantial evidence, however, suggests that it may not be satisfied. The coefficient on unanticipated money is a reduced form estimate of γ_1, the impact of the announced money stock as interest rates, plus the impact of the revision of expected future money stocks. To the extent that the coefficient on UM captures the latter effect, constraint (d) would not be satisfied.

Differences Across Sub-Samples

The clear differences in market behavior before and after October 1982 are reinforced by the descriptive statistics presented in table 2. The data sample was originally divided in October 1982 based on the belief that the Federal Reserve change from targeting the growth of nonborrowed reserves to smoothing changes in short-term interest rates may have significantly altered the informational content of money announcements.[10/]. Under interest rate smoothing, a number of changes would be expected: weekly changes in money would be larger, intraweek changes in interest rates would be smaller, and the variance or range of interest rate responses to the money announcement would be reduced. The data in table 2 support each of these expectations.

Comparing pre- and post-October 1982 data reveals that the average change in weekly money almost doubled from about $600 million before M1 was de-emphasized to over $1 billion after October 1982. Conversely, the average intraweek (Tuesday through Thursday) change in the three-month T-bill rate declined from 10 basis points to one basis point after the policy change while the standard deviation fell from .492 to .165. Finally, prior to October 1982, when nonborrowed reserves targeting and an

explicit M1 target implied that changes in M1 carried information relevant to future interest rate movements, the standard deviation of interest rate changes following the money announcement was 0.236. In addition, the range of interest changes was almost 200 basis points. In sharp contrast, data for the post-October 1982 period show this standard deviation reduced by one-half and the range of interest rates changes narrowing to less than 80 basis points. Based on this evidence, the data imply that the nonsignificance of past and expected changes in money after October 1982 is linked to a change in Fed policy that reduced the variability of short-term interest rates and abandoned the direct targeting of money.

VI. CONCLUSIONS

Recent studies of the weekly money announcement have found fully anticipated events to affect interest rates, a result often interpreted as implying rejection of the efficient markets hypothesis. Rather than drawing this conclusion, we have constructed a model with efficient markets as a maintained hypothesis that nonetheless attributes an important role both to actual past events and to expected future events. Our model hypothesizes that weekly money announcements are not independent events

but, over some period of weeks, may have a cumulative impact on the information set of market agents. Money announcements may alter expectations of future monetary policy. In addition, they may alter the interpretation of previous announcements. Simply stated, they reveal additional information concerning whether previous money shocks should be considered permanent or transitory.

Estimates of the model clearly show a significant role for both previous and expected events in explaining short-run movements in interest rates. Sub-sample results also indicate a clear change in interest rate response to money announcements following the Federal Reserve's October 1982 de-emphasis of M1. Overall, our results suggest that in a world where controlling money is the policy objective, agents will interpret individual money announcements relative to past announcements and future expectations.

FOOTNOTES

1/ See Hardouvelis (1984) and Sheehan (1985) for reviews of the empirical literature.

2/ For example, see Cornell (1982), Cornell (1983a), Hardouvelis (1984), Judd (1984), Loeys (1984), Pearce and Roley (1983), Roley (1982) and Roley and Troll (1983).

3/ For example, see Belongia and Kolb (1984), Belongia and Sheehan (1985), Roley (1983), Urich and Wachtel (1984) and Gavin and Karamouzis (1984).

Roley (1983) and Gavin and Karamouzis (1984) have attempted to attribute this result to an imperfect measure of expectations. In contrast, Hein (1985) has demonstrated empirically that making the appropriate adjustment to measured expectations does not alter the conclusion that, in the post-1979 period, expected money changes have influenced financial market variables. Roley (1985) contends, however, that Hein's experiment only shows expectations are not formed rationally.

4/ For example, in the federal funds market, larger interest rate fluctuations may be observed on Wednesdays as banks make last minute arrangements to meet reserve requirements. The "weekend effect" documented by Gibbons and Hess (1981) is another example.

5/ Note that a simple way of testing restriction (a) is to constrain $\alpha_j = 0$ for all j. This is a sufficient condition but would not be a necessary condition if monetary policymakers were following a monetary rule.

6/ See Sheehan (1985) for a more complete discussion of the information provided by the announcement.

7/ A sufficient condition for constraint (b) to hold is $\gamma_{j+1} = \gamma_j$ for all j's.

8/ See Roley (1983), Hein (1985) and Roley (1985) for a review of the debate concerning what adjustment to the Tuesday survey is appropriate given the availability of additional information after the survey.

9/ The lag lengths for ΔM are not determined by the underlying theory. Thus, Akiake's FPE is used to empirically ascertain the lag length. See Batten and Thornton (1984) for a discussion of alternate criteria.

10/ See Wallich (1984) and comments by Rasche (1984) for discussions of this change.

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Table 1
The Effects of Fully Anticipated Events in the Post-1979 Period

Variable	2/8/80 - 10/8/82		10/8/82 - 11/14/83		2/8/80 - 11/14/83	
	A	B	A	B	A	B
Intercept	-0.320	-0.268	-0.713	-0.724	-0.195	-0.225
	(1.04)	(0.90)	(1.84)	(1.84)	(1.38)	(1.62)
ΔM_{t-1}	0.010	0.011	--	--	0.006	0.006
	(1.71)	(1.94)			(1.38)	(1.53)
ΔM_{t-2}	0.027	0.029	--	--	0.017	0.019
	(4.42)	(4.96)			(3.86)	(4.26)
ΔM_{t-3}	0.019	0.022	--	--	0.012	0.013
	(3.13)	(3.64)			(2.68)	(3.07)
ΔM_{t-4}	0.009	0.009	--	--	--	--
	(1.53)	(1.53)				
EM	0.0006	0.0005	0.001	0.001	0.0004	0.0004
	(0.86)	(0.66)	(1.86)	(1.87)	(1.14)	(1.31)
UM	0.054	0.061	0.037	0.038	0.049	0.054
	(7.87)	(8.62)	(5.14)	(4.98)	(8.83)	(9.53)
Δi (T-Th)	--	-0.106	--	-0.034	--	-0.093
		(3.09)		(0.39)		(3.07
$\bar{R}^2$	0.36	0.40	0.31	0.30	0.33	0.36
D-W	1.95	1.87	2.28	2.27	1.92	1.86

Absolute values of t-statistics in parenthesis

Table 2
Descriptive Statistics for Data Before and After the De-emphasis of M1

	2/8/80 - 10/8/82 (n=132)			
Variable	Mean	Standard Deviation	Minimum	Maximum
Δi	-0.004	0.236	-0.75	1.13
ΔM	0.592	3.100	-6.10	13.00
EM	424.341	22.710	380.8	461.60
UM	0.295	2.392	-4.90	8.50
Δi (T-Th)	-0.101	0.492	-1.77	1.62

	10/8/82 - 11/14/83 (n=56)			
Variable	Mean	Standard Deviation	Minimum	Maximum
Δi	0.023	0.122	-0.33	0.44
ΔM	1.030	2.896	-3.30	7.20
EM	427.339	17.95	459.50	519.70
UM	0.350	1.965	-3.50	4.90
Δi (T-Th)	-0.011	0.165	-0.44	0.43