SHORT-TERM INTEREST RATES, WEEKLY MONEY ANNOUNCEMENTS AND RATIONAL FORECASTS

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ABSTRACT

Recently there have been a growing number of studies of the "money announcement" phenomenon. Towards the end of each week, the U.S. Federal Reserve Board announces its estimate of the narrowly defined monetary aggregate for the statement week ending some eight to ten days previously. The tendency for interest rates and other financial prices to respond to these "money announcements" has been well established. The importance of this phenomenon rests on the test it provides for the effect of monetary policy on real variables. However, existing tests incorporate at least two key assumptions. Firstly, that the Money Market Services, Inc. survey of market participants expectations is the best predictor (i.e., the rational expectation) of the weekly money announcement. Secondly, that the money announcement itself is the best predictor (i.e., the rational expectation) of the "true" change in the money supply (in practice, the true money supply is taken to be the final estimate after several data revisions). The analysis in this paper shows that both of these assumptions are rejected by the data. Readily available information can be used to improve upon both the Money Market Services forecast of the announcement and the Fed's own preliminary estimate of the "true" money supply change. This information is used to estimate rational expectations of the change in the money stock, both with respect to information available just before the announcement and that available just after the announcement. Appropriate econometric techniques are used with these "generated regressors" to obtain consistent and efficient estimates of the announcement effect on short-term interest rates. This enables tests to be calculated to determine whether this effect, and/or the structure of the forecasts, change in response to changes in Fed policy or in its measurement of the announced monetary data.

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1. Introduction

One of the most important issues in monetary economics is whether monetary policy has real effects. The real rate of interest provides a potential channel through which monetary policy may affect real activity. Recent empirical studies that attempt to test for monetary effects via this channel typically take one of two forms. An example of the first type is provided by Mishkin's (1983) tests for a contemporaneous effect of unanticipated monetary policy on interest rates. As Mishkin points out, however, such studies are beset by the familiar problem of simultaneous causality between interest rates and the money supply. Unless one is willing to assume that Federal Reserve policy is independent of current interest rates, the data can only be interpreted by first assuming a structural model of the relationship between interest rates and policy. Since there is no consensus on such a model, there is little likelihood of agreement over the interpretation of the empirical "evidence" obtained.

This has led to a second line of testing for the real effects of monetary policy. Towards the end of each week, the Fed announces its estimate of the narrowly defined monetary aggregate for the statement week ending some eight to ten days previously. These data circumvent the causation question. At the time of the announcement, the announced change in the money stock must be exogenous with respect to current Fed policy, interest rates and asset prices. Any correlations between this announcement and <u>subsequent</u> changes in interest rates or asset prices, will thus be evidence of causation from money to interest rates. They can not be interpreted as effects that run from interest rates to money.

These studies have typically found a significant, positive, effect of the announcement on interest rates. A rise in interest rates has been found to be associated with an unexpected increase in the money supply which is revealed by the announcement. Several authors have offered explanations for this positive response. There are four main contenders. By necessity, all of them share a common feature. The announcement can only affect interest rates by changing agents' expectations of variables. The effect must be through information sets, and not via other monetary transmission channels.[1]

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1. Although these channels will generally be necessary for the effects on expectations to lead to changes in real activity.

Cornell (1983) identifies these four explanations as the Keynesian, expected inflation, real activity and risk premium hypotheses. The Keynesian (or policy anticipation) hypothesis explains the correlation by suggesting that the announcement alters agents' expectations about future Fed policy. An unanticipated increase in the money stock will induce the Fed to tighten monetary policy in the future. In a Keynesian framework, anticipation of future monetary contraction leads to increases in real and nominal interest rates today.[2] Under the expected inflation hypothesis, an unanticipated increase in the money supply is interpreted as an upward revision in the Fed's operating target. This produces expectations of higher inflation in the future, raising the nominal interest rate now, via the well known Fisher equation.[3] There is no effect on real interest rates. The real activity (or signaling) hypothesis postulates that the money announcement provides a signal of fluctuations in future real activity by revealing unperceived information about money demand.[4] Hence, an unanticipated increase in the money stock implies that real activity will be higher than previously thought. This news induces an increase in interest rates. Finally, under the risk premium hypothesis, the money announcement provides agents with information about other agents' risk preferences and their beliefs about the riskiness of assets that compete with money.[5] For example, an unanticipated increase in the money stock may indicate that agents' view non-monetary assets as riskier than had previously been perceived, leading to a fall in the prices of these assets and a rise in interest rates.

These hypotheses each have different implications for the causal relationship between money and real interest rates. However, they have similar predictions for the response of short-term and long-term interest rates to the weekly money announcement.[6] This has lead to a proliferation of studies that seek

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2. See, for example, Urich and Wachtel (1981).

3. Cornell (1983) and Hardouvelis (1984) discuss this explanation in more detail.

4. Nichols, Small and Webster (1983) and Siegel (1985) provide different examples of this hypothesis. The interest rate response generally depends on the relationships between real output, interest rates and money.

5. See Cornell (1983).

6. Cornell (1982 and 1983), Gavin and Karamouzis (1984), Grossman (1981), Hardouvelis (1984), Loeys (1985), Roley (1983) and Urich and Wachtel (1981) all examine the response of short-term interest rates. The response of long-term rates is studied by Cornell (1983) and Gavin and Karamouzis (1984). Forward interest rates are examined by Gavin and Karamouzis (1984), Hardouvelis (1984), Loeys (1985) and Shiller et al (1983).

to distinguish among the hypotheses on the basis of the response of prices in other asset markets.[7] For instance, Hardouvelis (1984) looks at foreign interest rates and exchange rates. The latter are also examined by Cornell (1982 and 1983), Engel and Frankel (1984), Gavin and Karamouzis (1984) and Husted and Kitchen (1985). The stock market response is evaluated in studies by Cornell (1983) and Pearce and Roley (1984). Frankel and Hardouvelis (1985) study the response of commodity prices.

The net result of all these regressions has been an inability to distinguish among the competing hypotheses. Loeys (1985) concludes that even a hypothesis (suggested by Hardouvelis (1984) and formalised in Hardouvelis (1985)) that combines the policy anticipation and expected inflation explanations,[8] is only partially consistent with the data.

This paper does not attempt to wade into the muddy waters of testing these competing hypotheses. Rather, it takes the analysis back a step in focussing on two key assumptions that are implicitly made in all these studies.

Firstly, it has almost always been assumed that the survey data provided by Money Market Services Inc. provide the best predictor of the announced change in the money supply.[9] The results presented here reject the null hypothesis that the survey data provide a rational expectation of the announcement on the basis of information available just before the announcement. The gap between the announced change and the expected change as measured by the survey is not, therefore, the best measure of the news content of the Fed's announcement.

The second assumption also concerns news and is, perhaps, more important for the interpretation of these studies in terms of the wider issue of the relationship between money and real interest rates. The "news" relevant for this issue is that about the actual money stock. It is implicitly assumed in these studies that both the survey and the announcement provide rational expectations (with respect to the information sets available at the time) of the actual (as opposed to the announced) change in the money supply. The

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7. Cornell (1983) has a good discussion of the responses predicted by each hypothesis in the different markets.

8. The argument is that the lag structure of the economy is such that both effects work simultaneously with the first one dominating the response at the short end of the financial market and the second one dominating at the long end.

9. A partial exception is provided by Roley's (1983) adjustment of the survey data in one of three estimation periods.

analysis in this paper shows that neither the survey nor the announcement are rational predictors of this change relative to the other information available to agents. In particular, subsequent revisions made to the announced money supply data are partly forecastable at the time of the announcement. This suggests that agents who make efficient use of information would combine these announced data with other available data when forming their expectations. The gap between the announced change and the expected change as measured by the survey is not, therefore, the best measure of the unexpected money stock change. The maintenance of both these assumptions in previous studies biases the parameter estimates and invalidates the related hypothesis tests.

The analysis presented here takes these problems into account by estimating rational expectations of the change in the money stock. These are calculated both with respect to information available just before the announcement and that available just after the announcement. The former provides an estimate of the expected change, and the gap between them yields a measure of the money surprise. Appropriate econometric techniques (recently outlined in Pagan (1984)) are then used to obtain consistent and efficient estimates of the "announcement effect" on short-term interest rates. This enables tests to be calculated to determine whether this effect, and/or the structure of the forecasts, change in response to changes in Fed policy or in its measurement of the announcement data.

The remainder of the paper is in five sections. Section 2 outlines the model that has previously been used to measure the announcement effect, and the modifications that are necessary in the light of the inadequacies of the survey and announcement data. The next section discusses the estimation technique that is appropriate for the modified model. Forecasting equations for the survey and announced changes are obtained in Section 4, and the rationality tests presented. The estimation of the announcement effect, and the extent to which it has changed over time, is dealt with in Section 5. Some concluding comments are made in the final section.

2. The Model

(a) The Standard Model

The normal way of evaluating the response of interest rates to the information incorporated in the M1 announcement is to estimate the equation,

(1) $$\Delta r_t = \alpha + \beta U\Delta M_{t-2} + \gamma E\Delta M_{t-2} + \mu_t$$

where Δr_t is the change in the interest rate following the announcement in week t, $U\Delta M_{t-2}$ is the unexpected change (revealed by the announcement in week t) in the money supply for the statement week that ended eight to ten days previously, $E\Delta M_{t-2}$ is the change in the money supply that is expected prior to the announcement, and μ_t is a Normally distributed white noise disturbance term. Under the null hypothesis of efficient financial markets, the parameters α and γ should be zero.[10] The parameter β measures the announcement effect.

Studies of short-term rates have typically used measures of the change in the one-day Federal Funds rate and in the coupon-equivalent yield of a three-month Treasury Bill as the interest rate variables.[11] The expected change in the money supply is invariably measured by the median expected change from a sample survey conducted by Money Market Services Inc. of San Francisco.[12] This variable will be denoted by $S\Delta M_{t-2}$. The difference between the announced level of the money supply and the simultaneously announced revised level of the money supply for the preceding week, provides the measure of the announced change in the money supply which will be referred to as $A\Delta M_{t-2}$. The unanticipated change is then the difference between this figure and the expected change.[13] Algebraically this model, which will be named <u>Model S</u>, may be represented by appending the definitional equations,

(2.1) $E\Delta M_{t-2} \equiv S\Delta M_{t-2}$

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10. Many authors do not allow for a non-zero γ. To the extent that other studies (including the current one) find evidence of a non-zero γ, this is a further source of bias in previous results. See Cornell (1983) (and the comment by Falk and Orazem (1985)), Gavin and Karamouzis (1984), Grossman (1981) and Roley (1983).

11. The announcement is made between 4.00 p.m. and 4.30 p.m. EST. Some studies (Grossman (1981) and Roley (1983)) have used the change between 3.30 p.m. and 5.00 p.m. on the day of the announcement. This paper follows the bulk of the literature (Cornell (1982 and 1983), Gavin and Karamouzis (1984), Hardouvelis (1984) and Loeys (1985), among others) in using the change between 3.30 p.m. on the day of the announcement and 3.30 p.m. on the first market-operating day following the announcement.

12. This survey asks a number of government securities traders what money supply change they expect the Fed to announce later in the week.

13. Many authors convert the changes to growth terms. Given that the survey question and response is in terms of changes in billions of dollars, this study follows Roley (1983) in using changes to the money stock. For the sake of completeness, all of the calculations have been duplicated in growth rate terms and reported in the Appendix. No essential differences in the results are detectible. I am grateful to Michele Droop for performing these additional calculations.

$$(2.2) \qquad U\Delta M_{t-2} \equiv A\Delta M_{t-2} - S\Delta M_{t-2}$$

to the interest rate equation given by equation (1).

Almost all the studies proceed under two assumptions about these money supply statistics. Firstly, it is assumed that the survey measure is the best predictor of the change in the money supply, based on information available immediately before the announcement.[14] Secondly, it is assumed that both the survey and the announcement provide rational expectations (with respect to information sets available at the time) of the actual change in the money supply. The standard model is readily modified to enable these assumptions to be relaxed and tested.

(b) The Model with Rational Expectations

Some empirical evidence is available on the first of these issues, namely that the survey is the best predictor of the announced change in the money supply. For example, Urich and Wachtel (1984) report that (for the March 1978 to January 1980 period) they fail to reject this null hypothesis of rationality for the mean of the survey, although they can reject rationality for the responses of some individuals in the survey and for the pooled forecasts. Grossman (1981) and Roley (1983) also fail to reject this hypothesis for the median of the survey. These tests are usually the simple hypothesis of a zero intercept and unit coefficient in a regression of the announced change on the survey, or the comparison of the survey data with an ARIMA model of the announced change. As such, they provide little evidence on the orthogonality of the residual to other information available just before the announcement.[15]

To the extent that other information helps to forecast the announced change in the money supply, Model A is the appropriate method of measuring the announcement effect. This is defined with the aid of the identities,

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14. A partial exception is Roley (1983), where an adjustment is made to the survey data to account for a timing change in one of his three estimation periods. However, there are no tests for the orthogonality of other available data.

15. One exception is Grossman (1981) who found that information available at the time of the survey (several days earlier) was orthogonal during the September 1977 to September 1979 period. Engel and Frankel (1984) also showed that (between October 1979 and August 1981) the one month Eurodollar rate and the Dollar-Mark exchange rate, on the morning of the announcement, were orthogonal.

(3.1) $E\Delta M_{t-2} \equiv E[A\Delta M_{t-2} | I_t]$

(3.2) $U\Delta M_{t-2} \equiv A\Delta M_{t-2} - E[A\Delta M_{t-2} | I_t]$

where $E[A\Delta M_{t-2} | I_t]$ is the expected value of the announced change in the money supply given information available just before the announcement (including the median of the survey).

(c) The Model with Rational Expectations and the True Money Supply

The second key assumption is that the announced change in the money supply is the best available measure of the actual change in the money supply. However, it is known that the announced money stock will be subject to a number of future revisions. In subsequent weeks the Fed revises the first announced numbers to account for additional data received and for computational, reporting and other processing errors. At the end of each quarter the Fed receives balance sheets from non-member banks which lead to further revisions in the form of benchmark adjustments. The seasonal factors that are applied to the raw data are subject to a sequence of substantial revisions over a longer time frame. Finally the definition of the "M1" monetary aggregate, which is announced each week in the H6 release, may itself be significantly changed in the light of developments in financial markets. To the extent that parts of these revisions are forecastable from data available at the time of the announcement, the announced change may not be a rational forecast of the actual change in the money supply.

The empirical evidence on this issue is only suggestive. Marvall and Pierce (1983) show that the revision error (between the "final" and "first-announced" money stocks) is substantially due to the seasonal factor revisions and that it exhibits significant serial correlation.[16] This does not, however, necessarily imply that the revisions are forecastable, since ex-post revision errors to lagged money stocks may not be in agents' information sets ex-ante.[17] Mankiw, Runkle and Shapiro (1984) show that the preliminary announcement is not a rational forecast of the final money stock, but may be improved by accounting for information available in asset prices. Their analysis, however, is based on quarterly, seasonally unadjusted data for the

16. They use a monthly series of two-monthly rates of growth of seasonally adjusted M1, for the 1972 to 1979 period.

17. That is, the "final" value of the lagged money stocks will probably not be available ex-ante, so neither will the revision errors.

period from 1954 to 1978, whereas the announcement studies use weekly, seasonally adjusted data starting from the end of 1977. Given that the information flows under consideration are weekly, that this information may be of a temporary nature, that one of the largest components of the revisions are the seasonal factors and that there was substantial redefinition of M1 in the post 1978 period, the Mankiw et al results cannot be regarded as conclusive.

Nevertheless, if parts of the future revisions are forecastable from available information, then Model F is the appropriate one. Model F is defined by equation (1) in conjunction with,

(4.1) $E\Delta M_{t-2} \equiv E[F\Delta M_{t-2}|I_t]$

(4.2) $U\Delta M_{t-2} \equiv E[F\Delta M_{t-2}|\{I_t U I_A\}] - E[F\Delta M_{t-2}|I_t]$

where $E[F\Delta M_{t-2}|I_t]$ is the expected value of the final change in the money supply given information available just after the announcement (including the median of the survey), and $E[F\Delta M_{t-2}|\{I_t U I_A\}]$ is the expected value of the final change in the money supply given information available just after the announcement.[18]

(d) Some Additional Issues

There remain two other issues that are relevant to the measurement of the announcement effect. Firstly, the weekly H6 statistical release contains revised numbers for the money stock in a number of previous weeks, in the same table as the "announced" money stock. Until 15 February 1980, figures for the eight weeks prior to the statement week of the "announcement" were reported. Following this, figures were reported for between four and eight weeks prior to the statement week of the announcement. Since all existing explanations of the announcement effect involve its impact on expectations via an updating of agents' information sets, there is reason to believe that the information contained in these revisions may also have an impact on interest rates following their release.

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18. If permanent measurement errors exist, one should be interested in forecasting the actual ("unobservable at any point in time") change and not the "final" change. Given the "law of iterated projections" (Sargent (1979)), these forecasts will be the same providing that the "final" change is itself a rational predictor of the actual change, with respect to some information set that includes the information available just after the announcement. The only alternative would be to specify a model of the measurement error of each revision, and to estimate the equations using a Kalman filter technique.

Accordingly, equation (1) may be replaced by the more general expression,

(5) $$\Delta r_t = \alpha + \beta U\Delta M_{t-2} + \gamma E\Delta M_{t-2} + \Sigma_i \beta_i UR_i + \Sigma_i \gamma_i ER_i + \mu_t$$

where i runs from 1 through 7, and

(6.1) $$ER_i \equiv E[R_i | I_t]$$

(6.2) $$UR_i \equiv R_i - E[R_i | I_t]$$

where R_i is the announced revision to the change in the money supply that occurred i weeks prior to the statement week of the announcement,[19] and $E[R_i | I_t]$ is its expected value given information available just before the announcement. Model AR is then defined by the combination of these equations with equation (3) (the forecasts of the announced change) and Model FR is given by the system of equations (5), (6) and (4), which involves forecasts of the final change.

The second issue is that a growing amount of attention has been paid to the effects changes in Fed operating procedures have had on the parameters of the announcement equation. On 6 October 1979, the Fed announced that it was switching its operating target from the Federal Funds rate to nonborrowed reserves. This was then changed to a policy of borrowed reserve targeting on 5 October 1982. A further change occurred on 2 February 1984 when the Fed announced that it was replacing the lagged reserve accounting rules with almost contemporaneous reserve accounting.[20]

There are, however, other events during the period which may also effect the estimates of the announcement effect. Until 31 January 1980 the H6

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19. The revision to the change, rather than the revised value for the change, is used to avoid multicollinearity problems. When no revision is made, its value will be zero. Whereas the revised value will be the same as the value that was announced the previous week. This could be collinear with the current announcement.

20. Various authors have investigated the impact of these policy changes on the announcement effect on short-term interest rates. See, for instance, Cornell (1983), Gavin and Karamouzis (1984), Hardouvelis (1984) and Roley (1983). The consensus seems to be that the first change in Fed policy led to an increase in the announcement effect. Subsequent changes have substantially reduced it. Loeys (1985) is, however, the only one to present formal tests for parameter change.

statistical release was typically made public on Thursday afternoons.[21] It contained the announcement of the preliminary figure for the money supply for the week ending Wednesday, eight days earlier. On 8 February 1980 the normal H6 release day was changed to Fridays; it reported the estimate of the money supply for the week ending Wednesday, nine days earlier. The normal release day was changed back to Thursdays on 16 February 1984. In accordance with the new reserve accounting rules, it now reported the estimate of the money supply for the week ending Monday, ten days earlier. Perhaps more importantly, on 8 February 1980 the definition of the money supply aggregate reported in the H6 changed from "old" M1 to M1B (not "shift adjusted"). This aggregate was changed to "new" M1 (essentially a renaming) on the release of 15 January 1982.

Fortunately, the survey conducted by Money Market Services is defined to match the definitional changes in the announced money supply. This removes one source of difficulty, but leaves open the issue of whether these definitional and timing changes have effects on the parameters of the interest rate equations. Furthermore, shifts detected in the parameters of Model S due to these factors or to Fed policy changes, could be due to shifts in the parameters of the forecasting equations of Model A (equation (3)) or Model F (equation (4)), and not to shifts in the announcement effect itself (in the parameters α, β and γ of equation (1)).

3. The Estimation Technique

In order to estimate the forecasts of the various measures of the change in the money supply given by equations (3) and (4), and of the revisions in equation (6), the relevant information sets need to be defined. I_t is the set of information available to agents prior to the announcement. For simplicity, it will be assumed to contain the previous two announced changes, the previous two announced revisions to each of the seven lagged changes, the current and previous two survey-expected changes, the Federal Funds interest rate and 3-month T-Bill yield just before the announcement (and their two lagged values), and the changes to these interest rates following the two previous announcements.[22] The union of I_t and I_A is the set of information available

21. The release was not always made public on the "normal" day during any of the periods, for a variety of factors. The dates of the releases, and the rest of the data, are given in a Data Appendix available on request.

22. The specification of these information sets is by nature ad hoc. the multicollinearity in the information set caused by the relationships between the lagged values will not affect the properties of the estimates of agents' expectations.

after the announcement. I_A is the set of information revealed by the announcement. This consists of the announced change, and the announced revisions to each of the seven lagged changes.

The system of equations thus formed by each of the modified models (i.e., all models except Model S) involves "generated regressors", rather than observed data. Each takes the form,[23]

$$(7.1) \quad y = \beta(z-z^*) + \gamma z^* + \mu$$

$$(7.2) \quad z = z^* + \eta = \underline{w}\delta + \eta$$

where the asterisk denotes an expectational variable (i.e., a generated regressor), $\underline{w}$ is the vector of projection variables, and (for simplicity) z is a scalar.[24]

Barro (1977) estimated a similar system of equations using a 2-step estimator defined by first estimating equation (7.2) by OLS (ordinary least squares) to obtain $\hat{z}$ (an estimate of z*), and then estimating equation (7.1) by OLS using $\hat{z}$ as a proxy for z*. Mishkin (1982) suggested that this technique was inappropriate and advocated joint estimation by maximum likelihood. Recently, Pagan (1984) has shown that the limiting distribution of this 2-step estimator of the parameters β and γ and that of the maximum likelihood estimator, are the same.[25] The 2-step estimates are thus consistent and asymptotically efficient.

There is a problem, however, with the resulting estimates of the variances of the parameter estimates. The 2-step estimate of the variance of the estimate of β will be consistent, although that for the variance of the estimate of γ

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23. Roley (1983) is the only previous money announcement study to estimate a model of this form. However, he does not deal with the econometric issues discussed below.

24. The addition of an intercept, a vector of z's, or the complication produced in Model F where z is itself an expectation variable, do not affect the following discussion.

25. The extension of these results to the vector case requires that each z* variable be regressed on the same vector of projection variables, $\underline{w}$. This is to ensure that $\hat{z}_1$ does not help forecast $(z_2 - \hat{z}_2)$.

will be inconsistent.[26] Pagan (1984) shows that a consistent estimate of the variance of the γ estimate may be obtained by applying 2SLS (two-stage least squares) to the model formed from (7.2) and,

$$(7.1') \quad y = \gamma z + (\beta-\gamma)(z-z^*) + \mu = \gamma z + [(\beta-\gamma)\eta + \mu]$$

or by estimating equation (7.1') by IV (instrumental variables) with $\hat{z}$ used as an instrument for z. Alternatively, the error variance estimator obtained from the 2-step residuals of equation (7.1), may be replaced in the calculation of the variance of the γ estimate by the error variance estimator obtained by substituting z for $\hat{z}$ in the estimated equation.

The explanation is straight forward. The variance of the estimate of β depends on the variance of the residual μ, whereas the variance of the estimate of γ depends on the variance of the residual $[(\beta-\gamma)\eta + \mu]$. The 2-step estimator gives a consistent estimate of the former, and the other methods all yield consistent estimates of the latter. For some purposes, however, the 2-step results will suffice. For instance, if one is testing the null hypothesis H_0: $\gamma=0$, then the 2-step t-statistics will be overstated and acceptance of the null with the false standard errors must lead to acceptance with the correct standard errors.[27]

The estimates for Models F, FR, A and AR to be presented below are derived by using the 2-step estimator to estimate α, β, γ, and the standard errors for the β estimate. The standard errors for the estimates of α and γ are obtained by recalculating the variance formulae using the correct error variance estimate obtained by substituting z for $\hat{z}$ in the estimated 2-step equation.[28]

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26. Their covariance is zero, both at the theoretical level (due to the "orthogonality principle") and at the empirical level (due to the OLS "normal equations" in the first step). The comments made about γ also apply to the intercept, α, in an extended model.

27. See Pagan (1984).

28. The estimations were performed with release 82.3 of CMS SAS. The data are given in the Data Appendix available on request. A number of researchers seem to have encountered problems with data obtained from secondary sources. (See the comments by Vance Roley in the data appendix to his (1983) paper and Cornell's (1985) reply to the comment by Falk and Orazem (1985)). Data for this study were no exception. Data sets were originally obtained from four different secondary sources. In particular, none of them contained identical numbers for the money announcement. Jan Loeys, Vance Roley and Carl Walsh provided valuable assistance in obtaining these data and resolving the inconsistencies.

4. The Forecasting Equations

The Money Market Services survey was first published to coincide with the money announcement that was made on 29 September 1977. The estimation period starts two weeks after this to allow for the calculation of lagged values. It ends on 10 February 1984 which is the date of the last money announcement that was made on a week-ending-Wednesday basis, and the last one made before the Fed's switch to contemporaneous reserve accounting. There are 331 weekly observations in this estimation period. To allow tests for possible breaks in the estimated equations following changes in Fed operating procedures and the other factors that were discussed in Section 2, this period is divided into a number of subperiods. These are given in Table 1, where the dates are the dates of the relevant money announcements and n is the number of observations.

A further complication is introduced by the available data on the "final" money supply. Each March, the Fed publishes the "Money Stock Revisions" document. This provides the only available source of revisions to the seasonally adjusted, weekly money stock data. Unfortunately, the March 1983 issue is the most recent one that is available on a week-ending-Wednesday basis. This provides data up to and including the statement week ending 29 December 1982 which corresponds to the announcement made on 7 January 1983. Hence, Period 5 is truncated by 57 observations when estimating the parameters of the "final" forecasting equations.[29]

Table 1: Estimation Periods

Period	n	Start	End	Reasons for Break from Previous Period
1	104	10/13/77	10/04/79	
2	17	10/11/79	01/31/80	Fed switched to nonborrowed reserves
3	101	02/08/80	01/08/82	Switch to M1B, release day now Fridays
4	38	01/15/82	10/01/82	Definition changed to "new" M1
5	71	10/08/82	02/10/84	Fed switched to borrowed reserves

The information set available to agents before the announcement, I_t, contains thirty variables, including the constant term. It is clear from Table 1 that projections on this information set cannot be calculated for Period 2, and

29. Out of sample forecasts of the final change predicted by these equations are used to estimate the interest rate equations over the full length of Period 5.

that those for Period 4 would have few degrees of freedom. Fourteen of these variables are the two sets of lagged values of the announced revisions to each of the seven previous changes (i.e., the lagged R_i's). If these could be dropped from the information set there would be a significant increase in the degrees of freedom available for Period 4.

Table 2 presents the relevant F-tests for the null hypothesis that the coefficients of these fourteen variables are jointly zero. They are calculated for the forecasting equations for the final change given information just after the announcement (FA), and for the final change (F), the announced change (A) and the revisions (the R_i's) based on information just before the announcement.[30] Of the thirty F-statistics in Table 2, only one is significant at the 5% level of significance. This suggests that the fourteen lagged revisions may be dropped from the information set I_t.

Table 2: Lagged Revisions in Forecasting Equations[1]

Period	df1	df2	FA[2,3]	F[3]	A	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1	14	74	.19	.12	.84	.50	.79	.37	.96	.18	.21	.27
23	14	88	.61	.54	.62	.43	.41	.39	.63	.52	.38	.53
45	14	79	.52	.67	1.65°	1.41	1.43	.92	.76	1.89*	.74	.75

Notes: 1. These are the F statistics for testing the null hypothesis that the coefficients of the revisions, lagged once and twice, are zero in each of the forecasting equations for each period indicated. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. These statistics have df1 and (df2-8) degrees of freedom.

3. These statistics are not calculated for the truncated part of period 45. For this period, the second degree of freedom is reduced by 57.

30. The equations cannot be estimated separately for Periods 2 or 4. Other F-tests on the equations suggested that the breaks occurred between Periods 1 and 2, and between Periods 3 and 4. This issue is addressed in more detail, below, for the equations after the lagged revisions have been dropped.

The F-statistics for testing for the presence of breaks in the forecasting equations (once the lagged revisions have been dropped) are presented in Table 3.[31] The FA equation (the forecast of the final change after the announcement has been made), and a number of the revision equations, exhibit evidence of a break between Periods 3 and 4. This was when the monetary aggregate was switched from M1B to M1. Given that this change was essentially a renaming of the aggregate and not a redefinition, the explanation seems to lie in the effect this had on validating the wider definition of M1. The F equation (for the final change expected prior to the announcement) appears to have no breaks during the estimation period. The forecasting equation for the announcement, the A equation, shows evidence of a break at the end of Period 1. This coincides with the Fed's move to a nonborrowed reserves policy. No equation has a break between Periods 4 and 5 at the 5% level of significance. Equations for two of the revisions are the only ones to exhibit a break between Periods 2 and 3, when the release date was changed to the following day and the monetary aggregate was expanded to M1B. However, in both cases the break is less serious than the one between Periods 1 and 2.

Based on these results, the estimates obtained from Period 1, Period 23 (the union of the Periods 2 and 3) and Period 45 (likewise), will be used as the forecasting equations. Their properties are summarised in Tables 4 and 5.

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31. The left most column of this table gives the hypothesis being tested. For example, "H_0: 1=23" is the hypothesis that the parameters are the same in Period 1 as they are in Period 23. The overlap between the periods on each side of the equality in the first two rows of the table (e.g., 1=12), indicates a Chow test due to insufficient degrees of freedom for separate estimation of the forecasting equation in each distinct period.

Table 3: Breaks in Forecasting Equations[1]

H_0	df1	df2	FA[2]	F	A	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1=12	17	88	.49[3]	.40	1.27	3.17*	1.76*	.18	.18	.07	.17	6.28*
23= 3	17	85	.97[3]	.50	.34	2.22*	.65	.10	.13	.13	.11	3.40*
1=23	16	190	.73	1.39	2.35*	.87	.36	.28	.71	.31	.28	.12
3= 4	16	107	2.32*	.99	.80	.43	1.93*	3.96*	3.48*	1.26	1.04	2.21*
23= 4	16	124	2.13*	1.00	.78	.47	2.13*	4.63*	4.10*	1.35	1.19	1.74*
4= 5	16	77	1.30[4]	.58[5]	1.45	.67	1.38	1.51	1.58°	.89	1.44	1.75°
23=45	16	195	2.12*[6]	1.01[6]	1.04	.74	2.29*	4.45*	4.01*	2.09*	1.73*	2.14*

Notes: 1. These are the F statistics for testing the null hypothesis that the coefficients of each forecasting equation are the same in the two periods indicated. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. These statistics have (df1+8) and (df2-16) degrees of freedom.

3. The first degree of freedom is 17.

4. This statistic is not calculated for the truncated part of period. It has degrees of freedom 14 and 14.

5. This statistic is not calculated for the truncated part of period 5. It has degrees of freedom 14 and 22.

6. These statistics are not calculated for the truncated part of period 5. The second degree of freedom is reduced by 57.

Table 4: Forecasting the Revisions[1]

Period		R_1	R_2	R_3	R_4	R_5	R_6	R_7
1	R^2	.10	.17	.08	.14	.05	.04	.04
	dw	2.03	1.77°	2.07	2.00	2.01	2.04	2.04
23	R^2	.20°	.06	.08	.11	.18	.16	.03
	dw	2.07	1.93	2.12	1.99	2.09	2.04	2.41°
45	R^2	.18	.33*	.43*	.44*	.34*	.46*	.46*
	dw	2.01	2.14	2.29°	2.14	1.91	2.20°	2.24°

Notes: 1. An * (°) next to an R^2 denotes rejection of the null hypothesis that the explanatory power of the equation is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconclusive region.

Table 5: Forecasting the Money Supply[1]

		F: Final before announcement[2,4]					A: Announced[2]				
Period	df2	R^2	dw	$H_0 1$	$H_0 2$	$H_0 3$	R^2	dw	$H_0 1$	$H_0 2$	$H_0 3$
	df1			16	15	14			16	15	14
1	88	.12	2.63*	7.99*	8.29*	.46	.58*	1.86	2.15*	1.76°	1.76°
23	102	.31*	2.05	9.88*	10.26*	3.31*	.46*	1.97	2.07*	2.16*	1.96*
45	93	.41	2.28°	3.87*	3.71*	1.04	.58*	2.06	1.68°	1.52	1.59°

		FA: Final after announcement[3,4]					
Period	df2	R^2	dw	$H_0 4$	$H_0 5$	$H_0 6$	$H_0 7$
	df1			24	23	15	14
1	80	.23	2.79*	14.82*	15.91*	.29	.26
23	94	.51*	2.14	22.55*	23.51*	3.03*	1.74°
45	28	.79*	2.12	5.39*	5.62*	1.38	1.10

Notes: 1. An * (°) next to an R^2 denotes rejection of the null hypothesis that the explanatory power of the equation is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconclusive region. The remaining entries are F statistics for testing the relevant null hypothesis. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. $H_0 1$ is the hypothesis that the survey provides a rational expectation of the final or announced change, $H_0 2$ is the hypothesis that the survey provides an efficient forecast, and $H_0 3$ is the hypothesis that all other information is orthogonal.

3. $H_0 4$ is the hypothesis that the announcement provides a rational expectation of the final change, $H_0 5$ is the hypothesis that the announcement provides an efficient forecast, $H_0 6$ is the hypothesis that all other information is orthogonal, and $H_0 7$ is the hypothesis that all information other than the announcement and the survey is orthogonal.

4. These statistics are not calculated for the truncated part of period 45. For this period, the second degree of freedom is reduced by 57.

Table 4 presents the R^2 and Durbin-Watson statistics for the forecasting equations for the seven revision variables. None of the equations display any serial correlation in the residuals. However, only at the end of the sample period do the equations have any explanatory power. This suggests that the initial revisions are largely unforecastable.

The results for the announced and final change equations are presented in Table 5. The announced change is reasonably well forecastable from the information set. However, the hypothesis that the survey is a rational expectation of the announcement (hypothesis $H_0 1$) is rejected at the 10% level of significance for each period and at the 5% level for two of the three sub-periods.[32] When the hypothesis is relaxed slightly to allow for a non-zero intercept (hypothesis $H_0 2$ that the survey is a biased but efficient predictor), it is rejected at the 5% level for Period 23. The same result is obtained for the hypothesis that the other variables are orthogonal (hypothesis $H_0 3$), which allows for a non-unit coefficient on the survey variable as well as a non-zero intercept term. These results are in marked contrast to the usual assumption that the survey incorporates all the available information about the announcement. They show that Model A is preferred to Model S (the standard model) as a means of measuring the announcement effect.

The results for the final change variable are even more pronounced. Before the announcement, the final change is almost unpredictable.[33] The equation has forecasting power at the 5% level of significance in only one of the periods. Adding the announced change to the information set improves the predictability of the final change. Nevertheless, the announcement is not a rational expectation (hypothesis $H_0 4$), nor an efficient predictor (hypothesis $H_0 5$). However, including the survey in the equation does not in general improve the forecast it provides (hypothesis $H_0 6$). Nor does the inclusion of the other variables in the information set I_t (hypothesis $H_0 7$).

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32. This is the joint test that the intercept is zero, the coefficient on the survey is unity, and that the other variables have zero coefficients. In each period, the coefficient on the survey variable is not significantly different from unity. However, this is a necessary, not a sufficient, condition for rationality.

33. The presence of serial correlation in some of the final equations does not allow the predictability to be improved by adding lagged values of the dependent variable to the equation. This is because these were not in agents' information sets at that time.

Since the survey is not a rational expectation of either the announced or final changes, and the announced change is not a rational expectation of the final change, the F models are the appropriate vehicles for measuring the announcement effect. The results for these models are presented in the next section.

5. The Interest Rate Equations

Given the forecasting equations estimated for Periods 1, 23 and 45, one needs first to determine the appropriate estimation periods for the interest rate equations, and then to determine whether the models should be extended to include the revision (the "R" models). The F-tests for the relevant hypotheses are presented in Tables 6 and 7.

Table 6: Breaks in Interest Rate Equations[1]

		Federal Funds Rate					T-Bill Rate				
H_0	m, k	F[2]	FR[3]	A[2]	AR[3]	S[2]	F[2]	FR[3]	A[2]	AR[3]	S[2]
df1		17	17	17	17	17	17	17	17	17	17
1-12	101, 14	39.18*	33.87*	40.73*	34.42*	40.06*	7.38*	4.92*	7.35*	4.67*	7.64*
23-3	98, 14	.58	.93	.65	.94	.62	.64	.81	.53	.67	.71
df1		3	17	3	17	3	3	17	3	17	3
1-23	216, 28	2.16°	1.28	2.62°	1.54°	1.53	3.88*	1.70*	4.21*	1.29	7.06*
3-4	133, 28	1.43	.86	.05	.68	.29	7.24*	2.65*	1.24	1.55°	1.95
23-4	150, 28	1.79	.91	.11	.70	.30	7.22*	2.40*	1.26	1.45	1.62
4-5	103, 28	4.34*	1.24	2.16°	1.17	3.31*	4.15*	2.70*	.95	1.87*	1.55

Notes: 1. The entries are F statistics for testing the null hypothesis that the coefficients of each equation are the same in the two periods indicated. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. Under the null, these statistics have an F-distribution with df1 and m degrees of freedom.

3. Under the null, these statistics have an F-distribution with df1 and (m-k) degrees of freedom.

Table 7: Role of Revisions[1]

Period	df2	Federal Funds Rate Model AR $H_0 8$	Federal Funds Rate Model AR $H_0 9$	Federal Funds Rate Model FR $H_0 8$	Federal Funds Rate Model FR $H_0 9$	T-Bill Rate Model AR $H_0 8$	T-Bill Rate Model AR $H_0 9$	T-Bill Rate Model FR $H_0 8$	T-Bill Rate Model FR $H_0 9$
1	87	.49	1.06	.43	1.06	.73	.35	.36	.36
23	101	1.30	1.07	1.05	1.03	1.93°	1.06	2.70*	.62
4	21	.61	.39	.45	.41	1.21	.81	1.22	.66
5	54	.78	.21	.87	2.54*[2]	.33	.28	.63	.73[2]

Notes: 1. The entries are F statistics for testing the relevant null hypothesis. Under the null, these statistics have an F-distribution with 7 and df2 degrees of freedom for $H_0 8$, and 7 and (df2+8) degrees of freedom for $H_0 9$. $H_0 8$ is the hypothesis that the surprise parts of the revisions are jointly orthogonal, $H_0 9$ is the hypothesis that the expected parts of the revisions are jointly orthogonal. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively. (These tests are independent.)

2. These statistics are biased towards the rejection of the null hypothesis, and have 7 and df2 degrees of freedom.

Table 6 suggests that breaks occur between Periods 1 and 2, Periods 3 and 4, and Periods 4 and 5.[34] Surprisingly, no breaks are detected between Periods 2 and 3 (when M1 was replaced by M1B) for any of the models. Thus the results in Table 7 are presented for Periods 1, 23, 4 and 5. The only definite rejection of the null hypothesis that the revisions play no role in the interest rate equation, occurs for the T-Bill rate in Period 23, when Model FR is preferred to Model F. In all cases, Model F is the appropriate one, although the results in Models A and S will also be presented for purposes of comparison.

Looking again at Table 6, the breaks in the preferred models can be evaluated. For the T-Bill rate, Model F exhibits a break between Period 1 and Period 23, as do Models A and S. Hence, there was a significant change in the announcement effect following the Fed's move to a nonborrowed reserves

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34. The left most column of this table gives the hypothesis being tested. For example, "H_0: 1=23" is the hypothesis that the parameters are the same in Period 1 as they are in Period 23. The overlap between the periods on each side of the equality in the first two rows of the table, (e.g., 1=12) indicates a Chow test due to insufficient degrees of freedom for separate estimation.

policy.[35] Given that this was a move away from a policy of targeting the Federal Funds rate, it is a little surprising that the break between Period 1 and Period 23 in the equation for this interest rate is only significant at the 10% level.

The T-Bill rate equation also exhibits breaks between Periods 23 and 4 and between Periods 4 and 5. The latter is explained by the Fed's switch from a nonborrowed reserves policy to one focusing on borrowed reserves. The break at the end of Period 3 is a little puzzling. As in the case of the forecasting equations discussed above, the most likely explanation is that agents interpreted the "renaming" of the M1 aggregate as confirmation of a policy shift to a broader money measure. It is interesting to note that neither of the other models (A or S) detect either of these breaks in the announcement effect on the T-Bill rate.

The Fed's switch to borrowed reserves targeting (at the beginning of Period 5) also has a significant impact on the announcement effect for the Federal funds rate. This break is also detected by Model S, but not by Model A, at the 5% level of significance.

More information on the nature of these breaks in the interest rate equations is given by the parameter estimates presented in Table 8.[36] The change in Fed policy at the beginning of period 2 lead to breaks in Model F for both interest rates. Table 8 shows that it produced a sizeable increase in the announcement effect in both cases. The break that occurs in Model F at the end of Period 3 seems to be related to the role of the revisions and the expected change in the money supply. More will be said about this when the parameter estimates for the preferred model (Model FR) are presented.

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35. Loeys (1985) is the only other study to provide tests for parameter change. He also detected a significant break in the announcement effect on the T-Bill rate following this policy change. However, his tests are based on a variant of Model S where the constant term (α) is constrained to be the same in each period, and the expectation term (γ) is constrained to be zero. These assumptions produce biases in addition to those involved in using Model S. While they have not performed hypothesis tests, other authors have obtained results that have a similar pattern to the ones described here.

36. It has already been shown that Model FR is preferred in Period 23. These estimates will be presented separately. Those for Model F for this period and for Models A and S for all periods are presented for comparative purposes. The presence of serial correlation in the residuals of some of the equations for the Federal Funds rate presents a problem. However, under the hypothesis of market efficiency, they can not simply be re-estimated with lagged values of the interest rate as explanatory variables.

Table 6 showed that the second change in Fed policy, at the beginning of Period 5, produced a significant break in both interest rate equations for Model F. Examination of the parameter estimates shows that the effect of the announcement on these rates changed back to an effect of similar magnitude to that present under the original Fed policy during Period 1. This is in direct contrast to the results obtained from the standard model (Model S) for the T-Bill rate. Model S suggests that the expected change predicted by the survey had a separate impact on this interest rate in Period 5. Comparison with Model A indicates that this is probably due to the result that the survey is not a rational predictor of the announced changes.[37]

Table 8: Parameter Estimates[1]

Model&		Federal Funds Rate					T-Bill Rate				
Period	n-k	α	β	γ	R^2	dw	α	β	γ	R^2	dw
F 1	101	-.005	.018	.014	.01	1.94	.016	.090*	.012	.08*	1.73
		[.018]	[.029]	[.028]			[.019]	[.031]	[.030]		
F 23	115	.028	.421*	.087	.12*	2.49*	-.008	.293*	.168*	.27*	2.18
		[.079]	[.112]	[.093]			[.040]	[.056]	[.047]		
F 4	35	.089	.189*	-.114	.19*	2.56°	.068	.129*	-.103	.20*	1.80
		[.127]	[.074]	[.109]			[.096]	[.054]	[.082]		
F 5	68	.095	.013	-.025	.02	1.61°	.007	.018°	-.001	.05	2.02
		[.054][2]	[.017]	[.033][2]			[.030][2]	[.009]	[.018][2]		
A 1	101	.004	.001	-.001	.00	1.90	.023*	.017*	-.002	.05°	1.70°
		[.009]	[.007]	[.006]			[.010]	[.007]	[.006]		
A 23	115	.066	.115*	.008	.10*	2.43*	.066°	.091*	.013	.20*	1.91
		[.067]	[.033]	[.037]			[.036]	[.017]	[.020]		
A 4	35	.021	.111*	-.013	.15°	2.67*	.019	.059°	-.031	.11	1.76
		[.100]	[.045]	[.043]			[.074]	[.034]	[.031]		
A 5	68	.056*	.019	-.004	.03	1.69	.006	.022*	-.101	.16*	2.08
		[.027]	[.013]	[.012]			[.018]	[.007]	[.008]		
S 1	101	.010	.004	-.007	.01	1.89	.038*	.018*	-.012	.09*	1.68°
		[.011]	[.006]	[.007]			[.011]	[.006]	[.008]		
S 23	115	.056	.085*	.001	.07*	2.43*	.079*	.097*	-.087*	.31*	2.09
		[.066]	[.030]	[.062]			[.031]	[.014]	[.029]		
S 4	35	-.014	.106*	-.052	.24*	2.79*	-.006	.055*	-.059°	.20*	1.85
		[.080]	[.036]	[.039]			[.060]	[.027]	[.029]		
S 5	68	.049°	.017	-.007	.03	1.73	-.002	.023*	-.019*	.20*	2.05
		[.025]	[.012]	[.014]			[.013]	[.006]	[.007]		

Notes: 1. Estimated standard errors are given in square brackets. An * (°) next to a parameter estimate or R^2 denotes rejection of the null hypothesis that the corresponding population value is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconculsive region.

2. These estimated standard errors are biased towards zero.

37. Although, somewhat paradoxically, Table 5 suggests that it was "more" of a rational predictor in this period than in the earlier periods.

The results for the preferred model, Model F, suggest that the null hypothesis of market efficiency (i.e., that α and γ are both zero) cannot be rejected, except in the case of the T-Bill equation for Period 23 when Model FR is the preferred model. The relevant estimates for Model FR are,

$$
\begin{aligned}
(8)\quad \Delta rTB = & -.020 + .292^{*}U\Delta M + .176^{*}E\Delta M + .093UR_1 + .194UR_2 + .785^{\circ}UR_3 \\
& \;[.055]\quad [.058]\qquad [.061]\qquad [.079]\qquad [.190]\qquad [.403] \\
& -.783^{*}UR_4 + .228UR_5 - .926^{*}UR_6 + .439UR_7 - .075ER_1 \\
& \;[.317]\qquad [.356]\qquad [.356]\qquad [.633]\qquad [.283] \\
& -.029ER_2 - .782ER_3 - .118ER_4 + 2.39ER_5 - .230ER_6 - .349ER_7 \\
& \;[1.219]\quad [1.430]\quad [1.161]\quad [1.548]\quad [1.220]\quad [3.541]
\end{aligned}
$$

$R^2=.42^{*}$ $\quad$ dw=2.15 $\quad$ n-k=101 $\quad$ $H_0$10: F=1.82*, df1=8, df2=109

The estimates of β and γ are similar to those obtained from Model F and reported in Table 8. However, the unexpected components of the just announced revisions to the announced change in the money supply published three, four and six weeks earlier, also have an effect on the T-Bill rate in this period. None of the expected components of the revisions are significantly different from zero. However, the estimate of γ (the coefficient of $E\Delta M$) is significant. The hypothesis ($H_0$10) that all the expected values have zero coefficients, is rejected at the 5% level of significance by the appropriate F-test. This suggests that either the T-Bill market was inefficient during this period, that there is other information that needs to be taken into account when estimating the forecasting equations, or that a Type 1 error has occurred.

A comparison of the parameter estimates for Models A and S with those for Model F is interesting. For the Federal Funds rate, there is little difference in the parameter estimates of Models A and S. Model F, however, shows that the impact of the Fed's change to a nonborrowed reserves policy was much larger than would otherwise be detected. (Notice that the Period 1 announcement effect is zero in each model. Now compare the models for Period 23.)[38] For the T-Bill equations, Model S rejects the hypothesis of market efficiency for three of the four estimation periods.[39]

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38. This is consistent with the familiar econometric result that measurement errors tend to bias parameter estimates towards zero.

39. Similar results for market efficiency were obtained (using Model S) by Cornell (1985), Falk and Orazem (1985), Gavin and Karamouzis (1984), Grossman (1981), Roley (1983) and Urich and Wachtel (1981).

The most noticeable difference between Model F and the others is the estimates of β for both interest rates for Period 23. Table 9 shows that this is not simply due to the relative magnitudes of the final, announced and survey changes. The final and survey data are of a similar order of magnitude and the announced data are a lot noisier. However, there is nothing special about the relative variance sizes for Period 23. This suggests that the Fed's change from targeting the Federal Funds rate to a nonborrowed reserve policy, had a much larger effect on financial markets than has previously been appreciated from examination of the announcement effect.

Table 9: Money Supply Measures

Period	obs	Final mean	Final variance	Announced mean	Announced variance	Survey mean	Survey variance
1	104	.551	.872	.324	4.374	.727	1.522
23	118	.473	1.594	.426	6.821	.263	1.118
4	38	.558	3.020	.555	8.573	.053	4.092
5	71	1.050[1]	2.561[1]	.966	7.401	.646	2.761

Notes: 1. These statistics are calculated for the truncated part of period 5. The number of observations is reduced by 57.

Furthermore, the Model S results suggest that if the previous studies had tested for parameter change rather than comparing point estimates, they would only have detected a change in the T-Bill equation in response to the first change in Fed policy. Model F, on the other hand, suggests that breaks occurred in response to the shift to the "new" M1 aggregate, as well as to the second change in Fed operating targets.

6. Concluding Comments

Two important assumptions implicit in existing studies of the money stock announcement effect have been shown to be rejected by the data. The measure of the expected change in the money supply provided by the median of Money Market Services' survey, is not found to be a rational expectation of the change that is announced on the weekly H6 statistical release. Furthermore, neither these data nor the announced data are found to be rational expectations of the actual change in the money supply that occurred in the relevant statement week.

When these results are taken into account, the estimates of the announcement effect on short-term interest rates yield different inferences. The main difference for the Federal Funds rate is finding a much larger increase in the announcement effect following the Fed's change to a nonborrowed reserves operating policy in October 1979.

The differences for the T-bill rate are more substantial. The modified model provides evidence of a significant fall in the response of this interest rate following the October 1982 change in Fed operating policy (to a borrowed reserves target), as well as a significant increase following the earlier change. The 1982 response is not detected by hypothesis tests on the standard model. Moreover, the modified model removes many of the problems raised by the rejection of the market efficiency hypothesis in the standard model.

At least two puzzles remain for the period between these two changes in Fed policy. Firstly, the modified model rejects the market efficiency hypothesis for the period immediately following the first policy change (as does the standard model). Secondly, breaks in both the formation of expectations and in the announcement effect on the T-Bill interest rate, are detected following the renaming of the M1B aggregate to "new" M1.

Given that the modified model produces substantially different conclusions for a number of the hypotheses examined, it is likely to produce different inferences with respect to the announcement effect on longer-term interest rates and in other asset markets. The extent to which that will help distinguish between the different explanations of the announcement effect, and thus shed light on the efficacy of monetary policy, remains a topic for further research.

APPENDIX

ANALYSIS IN GROWTH RATES

Table 1: Estimation Periods

Period	n	Start	End	Reasons for Break from Previous Period
1	104	10/13/77	10/04/79	
2	17	10/11/79	01/31/80	Fed switched to nonborrowed reserves
3	101	02/08/80	01/08/82	Switch to M1B, release day now Fridays
4	38	01/15/82	10/01/82	Definition changed to "new" M1
5	71	10/08/82	02/10/84	Fed switched to borrowed reserves

Table 2: Lagged Revisions in Forecasting Equations[1]

Period	df1	df2	FA[2,3]	F[3]	A	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1	14	74	.19	.12	.85	.50	.78	.37	1.01	.19	.22	.25
23	14	88	.62	.56	.63	.46	.46	.46	.67	.52	.43	.57
45	14	79	1.22	1.06	1.64°	1.48	1.48	.98	.82	1.85*	.82	.82

Notes: 1. These are the F statistics for testing the null hypothesis that the coefficients of the revisions, lagged once and twice, are zero in each of the forecasting equations for each period indicated. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. These statistics have df1 and (df2-8) degrees of freedom.

3. These statistics are not calculated for the truncated part of period 45. For this period, the second degree of freedom is reduced by 57.

Table 3: Breaks in Forecasting Equations[1]

H_0	df1	df2	FA[2]	F	A	R_1	R_2	R_3	R_4	R_5	R_6	R_7
1=12	17	88	.40[3]	.33	1.17	2.79*	1.51	.15	.19	.07	.15	5.13*
23= 3	17	85	1.04[3]	.51	.39	2.48*	.70	.10	.15	.13	.11	3.30*
1=23	16	190	.65	1.22	2.49*	.94	.41	.31	.82	.32	.28	.14
3= 4	16	107	2.03*	.88	.71	.37	1.71	3.75*	3.32*	1.19	.91	1.93*
23= 4	16	124	1.79*	.85	.66	.43	1.86*	4.37*	3.92*	1.27	1.04	1.49
4= 5	16	77	1.26[4]	.55[5]	1.45	.70	1.32	1.48	1.53	.93	1.40	1.69°
23=45	16	195	1.85*[6]	.91[6]	1.05	.70	2.09*	4.35	3.95*	1.98*	1.53°	1.88*

Notes: 1. These are the F statistics for testing the null hypothesis that the coefficients of each forecasting equation are the same in the two periods indicated. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. These statistics have (df1+8) and (df2-16) degrees of freedom.

3. The first degree of freedom is 17.

4. This statistic is not calculated for the truncated part of period. It has degrees of freedom 14 and 14.

5. This statistic is not calculated for the truncated part of period 5. It has degrees of freedom 14 and 22.

6. These statistics are not calculated for the truncated part of period 5. The second degree of freedom is reduced by 57.

Table 4: Forecasting the Revisions[1]

Period		R_1	R_2	R_3	R_4	R_5	R_6	R_7
1	R^2	.10	.17	.07	.14	.05	.04	.04
	dw	2.02	1.76°	2.07	2.01	2.01	2.04	2.04
23	R^2	.19°	.06	.08	.11	.17	.15	.03
	dw	2.09	1.94	2.12	2.00	2.10	2.05	2.41°
45	R^2	.19	.34*	.44*	.45*	.36*	.46*	.47*
	dw	2.01	2.14	2.29°	2.14	1.94	2.20°	2.24°

Notes: 1. An * (°) next to an R^2 denotes rejection of the null hypothesis that the explanatory power of the equation is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconclusive region.

Table 5: Forecasting the Money Supply[1]

Period	df2	F: Final before announcement[2,4] R^2	dw	$H_0 1$	$H_0 2$	$H_0 3$	A: Announced[2] R^2	dw	$H_0 1$	$H_0 2$	$H_0 3$
df1				16	15	14			16	15	14
1	88	.11	2.66*	7.76*	8.03*	.42	.58*	1.86	2.09*	1.71°	1.71°
23	102	.31*	2.05	9.52*	9.90*	3.33*	.46*	1.97	2.11*	2.20*	2.02*
45	93	.41	2.29°	3.85*	3.70*	1.02	.58*	2.06	1.82°	1.63°	1.73°

Period	df2	FA: Final after announcement[3,4] R^2	dw	$H_0 4$	$H_0 5$	$H_0 6$	$H_0 7$
df1				24	23	15	14
1	80	.22	2.81*	14.01*	14.39*	.25	.23
23	94	.50*	2.13	21.25*	22.17*	2.93*	1.70°
45	28	.79*	2.11	5.64*	5.88*	1.41	1.12

Notes: 1. An * (°) next to an R^2 denotes rejection of the null hypothesis that the explanatory power of the equation is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconclusive region. The remaining entries are F statistics for testing the relevant null hypothesis. Under the null, these statistics have an F-distribution with df1 and df2 degrees of freedom. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. $H_0 1$ is the hypothesis that the survey provides a rational expectation of the final or announced change, $H_0 2$ is the hypothesis that the survey provides an efficient forecast, and $H_0 3$ is the hypothesis that all other information is orthogonal.

3. $H_0 4$ is the hypothesis that the announcement provides a rational expectation of the final change, $H_0 5$ is the hypothesis that the announcement provides an efficient forecast, $H_0 6$ is the hypothesis that all other information is orthogonal, and $H_0 7$ is the hypothesis that all information other than the announcement and the survey is orthogonal.

4. These statistics are not calculated for the truncated part of period 45. For this period, the second degree of freedom is reduced by 57.

Table 6: Breaks in Interest Rate Equations[1]

H_0	m, k	Federal Funds Rate F[2]	FR[3]	A[2]	AR[3]	S[2]	T-Bill Rate F[2]	FR[3]	A[2]	AR[3]	S[2]
df1		17	17	17	17	17	17	17	17	17	17
1=12	101, 14	39.63*	34.00*	40.76*	34.48*	40.15*	7.43*	5.13*	7.37*	4.86*	7.66*
23=3	98, 14	.58	.94	.66	.95	.62	.65	.77	.53	.65	.72
df1		3	17	3	17	3	3	17	3	17	3
1=23	216, 28	2.81*	1.54	3.36*	1.84*	1.93	5.12*	2.00*	5.21*	1.58°	8.79*
3=4	133, 28	1.30	.88	.05	.75	.32	6.48*	2.45*	1.20	1.54°	1.62
23=4	150, 28	1.62	.92	.11	.77	.34	6.40*	2.25*	1.22	1.46	1.27
4=5	103, 28	4.29*	1.19	2.03	1.25	2.97*	4.15*	2.45*	.97	1.76*	1.27

Notes: 1. The entries are F statistics for testing the null hypothesis that the coefficients of each equation are the same in the two periods indicated. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively.

2. Under the null, these statistics have an F-distribution with df1 and m degrees of freedom.

3. Under the null, these statistics have an F-distribution with df1 and (m-k) degrees of freedom.

Table 7: Role of Revisions[1]

		Federal Funds Rate				T-Bill Rate			
		Model AR		Model FR		Model AR		Model FR	
Period	df2	H_08	H_09	H_08	H_09	H_08	H_09	H_08	H_09
1	87	.50	1.05	.45	1.05	.75	.35	.37	.36
23	101	1.33	1.14	1.09	1.10	2.07°	1.04	2.88*	.57
4	21	.69	.36	.52	.37	1.21	.79	1.20	.69
5	54	.73	.20	.80	2.50*[2]	.33	.32	.666	1.11[2]

Notes: 1. The entries are F statistics for testing the relevant null hypothesis. Under the null, these statistics have an F-distribution with 7 and df2 degrees of freedom for H_08, and 7 and (df2+8) degrees of freedom for H_09. H_08 is the hypothesis that the surprise parts of the revisions are jointly orthogonal, H_09 is the hypothesis that the expected parts of the revisions are jointly orthogonal. An * (°) denotes rejection of the null hypothesis at the 5% (10%) level of significance, respectively. (These tests are independent.)

2. These statistics are biased towards the rejection of the null hypothesis, and have 7 and df2 degrees of freedom.

Table 8: Parameter Estimates[1]

Model& Period	n-k	Federal Funds Rate α	β	γ	R^2	dw	T-Bill Rate α	β	γ	R^2	dw
F 1	101	-.002	.058	.034	.00	1.93	.021	.313*	.010	.08*	1.71
		[.018]	[.104]	[.100]			[.019]	[.109]	[.109]		
F 23	115	.033	1.761*	.319	.12*	2.50*	-.005	1.176*	.663*	.26*	2.17
		[.078]	[.455]	[.374]			[.040]	[.227]	[.191]		
F 4	35	.089	.857*	-.525	.19*	2.56°	.068	.585*	-.478	.20*	1.81
		[.128]	[.333]	[.467]			[.097]	[.243]	[.377]		
F 5	68	.094°	.062	-.112	.02	1.61	.004	.086°	.009	.05	2.01
		[.055][2]	[.082]	[.157][2]			[.030][2]	[.448]	[.086][2]		
A 1	101	.004	.001	-.005	.00	1.90	.023*	.058*	-.009	.05°	1.70
		[.009]	[.024]	[.020]			[.010]	[.025]	[.022]		
A 23	115	.067	.489*	.021	.10*	2.44*	.065°	.367*	.058	.20*	1.91
		[.067]	[.134]	[.152]			[.036]	[.069]	[.081]		
A 4	35	.022	.508*	-.071	.16°	2.67*	.020	.276°	-.150	.12°	1.76
		[.100]	[.202]	[.193]			[.074]	[.151]	[.144]		
A 5	68	.055*	.093	-.013	.03	1.69	.005	.109*	-.044	.15*	2.09
		[.027]	[.065]	[.060]			[.018]	[.034]	[.039]		
S 1	101	.010	.013	-.025	.01	1.89	.039*	.062*	-.044	.09*	1.69°
		[.011]	[.021]	[.026]			[.011]	[.022]	[.027]		
S 23	115	.055	.354*	-.005	.07*	2.44*	.079*	.394*	-.356*	.31*	2.08
		[.066]	[.121]	[.253]			[.031]	[.057]	[.119]		
S 4	35	-.014	.479*	-.237	.24*	2.79*	-.006	.248*	-.264°	.20*	1.84
		[.080]	[.160]	[.175]			[.060]	[.121]	[.132]		
S 5	68	.048°	.083	-.028	.03	1.73	-.003	.114*	-.090*	.20*	2.06
		[.025]	[.062]	[.071]			[.013]	[.031]	[.036]		

Notes: 1. Estimated standard errors are given in square brackets. An * (°) next to a parameter estimate or R^2 denotes rejection of the null hypothesis that the corresponding population value is zero at the 5% (10%) level of significance, respectively. An * next to a Durbin-Watson (dw) statistic denotes rejection of the null hypothesis of no autocorrelation at the 5% level of significance; a ° indicates that the dw statistic falls within the inconculsive region.

2. These estimated standard errors are biased towards zero.

$$(8)\quad \Delta rTB = \underset{[.054]}{-.013} + \underset{[.236]}{1.174^{*}U\Delta M} + \underset{[.250]}{.691^{*}E\Delta M} + \underset{[.314]}{.369UR_1} + \underset{[.756]}{.728UR_2}$$

$$+\underset{[1.691]}{3.295^{\circ}UR_3} - \underset{[1.285]}{3.296^{*}UR_4} + \underset{[1.531]}{.712UR_5} - \underset{[1.510]}{4.053^{*}UR_6} + \underset{[2.486]}{1.595UR_7}$$

$$\underset{[1.180]}{-.308ER_1} + \underset{[4.906]}{.158ER_2} - \underset{[6.131]}{2.448ER_3} - \underset{[4.721]}{.159ER_4} + \underset{[6.751]}{1.369ER_5}$$

$$\underset{[5.299]}{-1.136ER_6} + \underset{[13.856]}{.255ER_7}$$

R^2 = 4.2* dw=2.14 n-k=101 $H_0$10: F=1.68 df1 = 8, df2 = 109

Table 9: Money Supply Measures[1]

Period	obs	Final mean	Final variance	Announced mean	Announced variance	Survey mean	Survey variance
1	104	1.547	7.306	.935	35.208	2.068	12.419
23	118	1.148	9.827	1.064	40.600	.654	6.608
4	38	1.240	14.886	1.256	42.912	.130	20.254
5	71	2.237[2]	11.492[2]	1.983	30.172	1.297	11.382

Notes: 1. These values refer to the percentage change in the money supply multiplied by a factor of ten.

2. These statistics are calculated for the truncated part of period 5. The number of observations is reduced by 57.

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