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A Note on the Temporal Stability of the Interest Rate-Weekly Money Relationship

by MICHAEL T. BELONGIA, R. W. HAFER and
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1. INTRODUCTION

A substantial body of work has investigated the effects of weekly money announcements on interest rates and other financial variables.[1/] The effects of expected and unexpected changes in money have been compared across time with sample periods determined by alleged changes in monetary policy regimes. The most frequently recognized change is October 6, 1979, when the Fed announced its shift from controlling the federal funds rate to a policy aimed at more directly influencing the behavior of reserves. Other break points often cited are February 8, 1980, when the money announcement day changed from Thursday to Friday, and October 1982 when the Fed announced a policy of reducing emphasis on M1 as a guide to policy.[2/]

Although an analysis of policy implementation would suggest these occurrences are likely points of change, other candidates also exist.[3/] Our purpose in this paper is to assess the structural stability of the relationship between short-term changes in the 3-month Treasury bill rate (hereafter Tbill) and changes in weekly money (M1) by using procedures to test for statistical changes in the relationship that do not rely on the a priori selection of break points. The two approaches used are time-varying parameter estimation and a recent temporal stability test suggested by Ashley (1984).[4/]

2. THE MODEL

The relationship between changes in interest rates and the weekly change in M1 often is tested by estimating the equation

$$(1) \quad \Delta i_t = \beta_0 + \beta_1 EM_t + \beta_2 UM_t + \varepsilon_t$$

where Δi is the change in the Tbill, EM is the expected change in M1, UM is the unanticipated component of the change in M1, and ε_t is a random error term. Because market efficiency requires that new information be disseminated rapidly through the market, the Δi term is measured as the 3:30 p.m. to 5:00 p.m. (EST) change in rates on the day of the money announcement.[5/]

Measuring UM and EM is made possible by the existence of a weekly survey by Money Market Services, Inc. (MMS). This firm polls a sample of government securities dealers during the week prior to the announcement to get their predictions of the upcoming announcement. From this survey a median forecast of the change in M1 (EM) is constructed. Subtracting this expected change from the actual change provides us with the unanticipated change in money (UM).[6/]

Because the timing of the survey changed during our sample, direct estimation of equation (1) may not be appropriate. Prior to February 1980, MMS conducted its survey on Tuesday and Thursday, the latter day being used to allow the forecasters to revise their Tuesday forecasts. From February 1980 through early 1984, when the money announcement was made on Friday, MMS conducted only a Tuesday survey, thus restricting the use of information available to forecasters relative to the earlier procedure. Roley (1983) argues that this change makes estimation of equation (1) using unadjusted survey data incorrect, because agents acquire and evaluate additional information between the time of the survey and the money announcement. If the additional information causes expectations to be revised, both EM and UM are not measured properly using only the MMS survey measure.

To adjust for this change in the information set available to forecasters just prior to the money announcement, we use the more general model:

$$(2) \quad \Delta i_t = \lambda_0 + \lambda_1 EM_t + \lambda_2 (M_t - EM_t) + \lambda_3 \ TBCH_t + \varepsilon_t$$

where TBCH represents the change in the Tbill rate from the market close on the survey date to 3:30 p.m. on the day of the money announcement.[7/] As Roley (1985) notes, this term captures the incremental information available to forecasters on the day of the money announcement, but not available on the day of the survey.

3. EMPIRICAL RESULTS

To investigate the temporal stability of the relationship embodied in equation (2), the following format is used: We first employ a time-varying parameter model. This model, following Garbade (1977), provides both statistical and visual evidence on the time-varying response of the Tbill rate to changes in each right-hand-side variable. The sample period used extends from the week of January 5, 1978 through the week of October 28, 1983. In addition, we employ the stabilogram test of Ashley (1984) to state precisely the average responsiveness over alternate intervals.

3.1 Time-Varying Parameter Model

Previous tests for structural change in equation (2) are based on the assumption that the relationship being examined underwent a discrete change. In contrast, the announcement of a change in the conduct of monetary policy may result in only a gradual evolution rather than a sudden shift in parameters, depending on the perceived credibility of the policy maker. Since the equation is based on market perceptions, it is the response of market perceptions to changes in operating procedures, policy goals, and the institutional environment that is of interest. Market perceptions may change only gradually--even if there is a discrete shift in the actual event. In this case, a time varying parameters approach would be a more appropriate estimation technique than those based on the assumption of a discrete shift.

The time varying parameter estimation begins by estimating equation (2) with the λ_i's replaced with $\lambda_{i,t}$'s where $\lambda_{i,t}$ is assumed to follow a random walk with zero drift over time $\lambda_{i,t} = \lambda_{i,t-1} + \rho_{i,t}$ where $\rho_{i,t} \sim \eta(0, \sigma^2 P)$. When P equals zero, this technique reduces to OLS.[8/]

One of the four parameters in equation (2) is allowed to vary while the others are held constant. The process is repeated sequentially for each of the four parameters. Maximum likelihood estimation (MLE) implies that the likelihood function is maximized for $\rho_0 = \rho_1 = 0$ for the coefficients on the constant term and on expected money: the null hypothesis of a constant coefficient cannot be rejected. In addition, the MLE result for TBCH yields a ρ_3 value of .04, with a likelihood function value of 718.65 vs. the OLS value of 718.10. The resulting χ^2 statistic of 1.09 is not significant at conventional significance levels. For unexpected money, the value of ρ_2 is even smaller, .03. The likelihood function is 731.66, however, resulting in a significant χ^2 statistic of 27.12. These results suggest that only the coefficient on unexpected money varies significantly over the sample period.

When all four parameters are allowed to vary simultaneously, the likelihood function is maximized with respect to all four diagonal elements. The MLE results now imply ρ_2 = .06 and ρ_3 = 1.6 while ρ_0 = 0 = ρ_1. Expected money and the constant still have stable coefficients while unexpected money and TBCH have varying parameters. The likelihood function increases to 735.59 while $\hat{\sigma}$ decreases from .00426 (when only the coefficient on unexpected money was allowed to vary) to .00337. These results, of course, only suggest significant parameter variation in the coefficients on unexpected money and TBCH. In addition, the coefficient on expected money is constant (-.0164) and significant (t-statistic of -3.02). This result, similar to results by Hein (1985) and Falk and Orazem (1985) for different samples, rejects the efficient markets hypothesis and is discussed at greater length below.

To capture the behavior of the time-varying parameters visually over our sample period, the coefficients on TBCH and unexpected money are plotted in figures 1 and 2, respectively. On each plot, dates of various peaks and troughs are listed. The plots show relatively little coefficient variation during the pre-October 1979 period. The coefficient on unexpected money appears to increase gradually over the period while the coefficient on TBCH remains basically unchanged and is insignificant throughout. The post-October 1982 coefficients evidence gradual change. The coefficient on unexpected money initially drops after the October 1982 change but within six months returns to approximately its previous level. In contrast, the TBCH coefficient falls gradually throughout the post-October 1982 period.

The intervening October 1979 - September 1982 period, however, exhibits substantially more irregular coefficients. The coefficients on unexpected money indicate a large temporary increase in impact in the first half of 1981. This increase occurs during the introductory phase of the nationwide NOW accounts. The behavior of the unexpected money coefficient may represent the uncertainty held by market participants in their forecast of M1. During the first half of 1981, the "moneyness" of the funds flowing into the new accounts was debated since a large portion came from savings deposits. The Federal Reserve attempted to quantify the portion of M1 that came from non-transaction accounts and provided a "shift-adjusted" measure that purportedly captured the increase in the non-transaction component of M1. Financial market participants may have believed there was a higher informational content in the unexpected component of the announcement.[9]

Unexpected money, on average, appears to have a slightly larger impact after this spike than before, a finding that accords with previous results. TBCH has smaller spikes in March 1980 (positive) and January 1981 and December 1981 to January 1982 (both negative). Despite considerable variation in coefficient estimates, none of the results suggests a dramatic shift in the impact of unexpected money on the Tbill rate either in October 1979 or in October 1982. The implication is that the imposition of discrete sample endpoints, as has been the common practice, is inappropriate.

3.2 Stabilogram Tests

Ashley (1985) suggests a simple test of coefficient stability which, based on Monte Carlo simulations, has power comparable to relatively more sophisticated techniques. To implement this test, the full sample is broken into N approximately equal parts. Individual (0, 1) dummy variables are assigned to each subperiod and are used to form interaction terms with each of the independent variables. The modified equation imposes N-1 linear restrictions on the model that are tested using an F-test. Moreover, estimation of the full model provides N period estimates of each coefficient.

This procedure was applied to equation (2), where the full sample period was divided into 11 half-year partitions.[10/] The estimated coefficients and the stabilogram test statistics are reported in table 1. The individual coefficient estimates for expected money and TBCH are rarely significant. For example, expected money achieves significance only during the first-half of 1981, a period characterized by the nationwide introduction of NOW accounts. The coefficient on TBCH also is significant during this period and again in the first-half of 1982. Indeed, the relatively few number of periods during which these two variables are significant suggests that the time-varying results, as well as OLS results based on a priori intervals, may be influenced by the data from these two relatively short periods.

The stabilogram results reveal a significant effect for unanticipated money over most of the sample, although its coefficient is generally insignificant in the pre-October 1979 period. Interestingly, unanticipated money's coefficient is significant in every period after 1979, except the first half of 1980. It should be recalled that this period includes the Special Credit Control program initiated by the Carter administration.

F-tests are used to test for parameter stability across all subperiods. These F-statistics, reported at the bottom of table 1, apply to the null hypothesis that $\lambda_{i,1} = \lambda_{i,2} = \ldots = \lambda_{i,11}$ where the second subscript refers to the individual subperiod estimates used. The null hypothesis of coefficient stability is rejected at uniformly high levels of significance for all coefficients except the constant term. This result together with the time-varying parameter evidence suggests that the results reported in previous studies may be misleading.

3.3 Further Evidence

The time varying parameter and stabilogram results suggest that there may be breakpoints besides October 1979 and October 1982. In particular, the results raise a puzzle concerning the significance of a break in 1981 indicated by our tests but not previously discussed.

An examination of the estimated residuals from the Ashley regressions suggests that a potential explanation for (1) finding a breakpoint early in 1981 and (2) the significance of expected money is the existence of one week in which benchmark revisions to M1 coincided with a so-called social security week.[11/] This week--May 1, 1981--is associated with the largest 3:30-5:00 change in the Tbill rate for the entire sample: 113 basis points. In addition, there occurred a relatively large \$4.1 billion error in predicting the change in M1.

To determine the importance of this one week, the 1/5/81-6/26/81 interval was re-estimated with the addition of a dummy variable equal to unity for the week of May 1 and zero elsewhere. The results are (absolute values of t-statistics in parenthesis):

$$(3) \quad \Delta i_t = \underset{(1.97)}{-\ 0.91} \ \underset{(1.69)}{-\ 0.069}\ EM_t \ \underset{(3.07)}{+\ 0.056}\ UM \ \underset{(2.90)}{-\ 0.213}\ TBCH \ \underset{(4.03)}{+\ 0.981}\ D$$

Accounting for the unusual circumstances associated with this one observation reduces expected money's coefficient both in magnitude (- 0.119 to - 0.069) and in significance. Removing the week of May 1, 1981 leaves expected money insignificantly different from zero at the 5 percent level in each subperiod. Moreover, results from the stabilogram test now fail to reject the null hypothesis of a stable coefficient on expected money (F-statistic of 1.19 significant at the 30 percent level).

It should be noted, however, that removing this single observation had no impact on the significance or stability of expected money in a re-estimation of the time-varying parameter model.

4. CONCLUSION

Taking an agnostic view of how changes in monetary policy affects the reaction of interest rates to surprises in weekly money announcements, we discovered a temporal path for coefficient estimates that differed in both timing and magnitude from what has been assumed in the previous literature. Whereas existing empirical evidence imposes discrete changes in the policy regime and the presumed interest rate response to money surprises, our results indicate a gradual, error-learning type of response to announced policy changes. Moreover, the time-varying parameter results indicate changes in the interest rate-money announcements relationship at points in time associated with various steps in the process of financial deregulation that have not been investigated in previous work. Our main result is that the existing literature has tested the efficient markets hypothesis with respect to the weekly money announcements by imposing discrete break points on the sample data when the market reactions to policy changes appear to be gradual and occur at different points in time.

In the absence of arbitrary breaks in the sample period, our results indicate that unexpected changes in M1 influence the three-month Tbill rate in a reliable fashion beginning in the second half of 1979. Our evidence indicates a drop in its effect during early 1980, a period associated with the Special Credit Control program, and a dramatic increase in early 1981. The evidence also indicates no marked reduction in unexpected money's impact after October 1982. Expected money's impact on the change in interest rates is sensitive to the estimation period. Moreover, our evidence indicates that the significance of this term, at least in early 1981, is due to one observation point. Removal of that week's effect reduces expected money to insignificance.

FOOTNOTES

1/ See the survey articles by Cornell (1983) and Sheehan (1985) and the references cited therein.

2/ For a useful discussion of these three policy changes, see Gilbert (1985). See also Lindsey (1984) for a discussion of monetary regimes and an interpretation of policy changes during the period since 1979.

3/ These include the imposition and subsequent removal of the conditions underlying the Special Credit Control program initiated by the Carter administration in 1980; the nationwide introduction of NOW accounts in January 1981; the introduction of money market deposit accounts (MMDAs) in late 1982; and the introduction of Super NOW accounts in early 1983.

4/ Loeys (1985) attempts to identify breakpoints using an alternate procedure based on estimating equations using a rolling time series.

5/ Belongia and Sheehan (1985) note that many studies rejecting the significance of expected money measure the change in interest rates over an interval of several days, from the Friday announcement day close to the Monday market close. They find expected money has a significant effect when changes in interest rates are measured over a more appropriate 90 minute interval from just prior to just after the announcement. Falk and Orazem (1985) also demonstrate that properly measuring the interest rate change in Cornell (1983) leads to the conclusion that expected money significantly influences the change in the interest rate after the money stock announcement. In the evidence presented below, we provide a possible explanation for this finding.

6/ Actual changes in M1 are taken from the Federal Reserve's H.6 statistical release. The actual change is measured as the first-announced minus first-revised M1 figure. Because the definition of M1 changed during our sample, the following procedure is followed: until February 1980, we use the old definition of M1. From February 1980 through November 1981, the money stock is defined as M1B, not adjusted for NOW accounts. Then, from November 1981 through the end of our sample, the current definition of M1 is used.

7/ Roley argues that correct measures for EM and UM are the estimated and residual values from the equation:

$$M_t = \alpha_0 + \alpha_1 EM_t + \alpha_2 TBCH_t + \eta_t.$$

Hein (1985) has argued that generating such a measure merely acts to correct the survey forecast (EM) for any existing bias, since α_0 and α_1 are freely estimated rather than restricted to $\alpha_0 = 0$ and $\alpha_1 = 1.0$, their values under the constraint of unbiasedness.

The above equation can be rewritten as:

$$UM_t = - \alpha_0 + M_t - \alpha_1 EM_t - \alpha_2 TBCH_t.$$

where $UM_t \equiv \eta_t$. Substituting into equation (1) and rearranging yields equation (2) in the text. The reduced-form parameters are related to the structural parameters in the following manner: $\lambda_0 = (\beta_0 - \beta_2\alpha_0)$; $\lambda_1 = \beta_1 + \beta_2 - \beta_2 \alpha_1$; $\lambda_2 = \beta_2$; and $\lambda_3 = - \beta_2 \alpha_2$. Note that if we impose unbiasedness on the survey forecasts, that is, $\alpha_0 = 0$ and $\alpha_1 = 1.0$, then $\lambda_0 = \beta_0$ and $\lambda_1 = \beta_1$. This restriction does not, however, remove the influence of TBCH. Following Roley's (1985) argument, equation (2) is estimated to augment the information set upon which the unanticipated money measure is calculated, rather than to correct the survey measure for possible biases.

8/The procedure, described in detail in Garbade (1977), is based on a concentrated log-likelihood function that yields a maximum likelihood estimator for P and plots of the estimated coefficients over time. Whether the MLE value $\hat{P}$ is different from the OLS value can be tested with the statistic $-2(L(P_0) - L(P))$ where $L(P_0)$ is the value of the likelihood function evaluated at $\hat{P}$ equal zero and $L(P)$ is the likelihood function evaluated at the MLE $\hat{P}$. This statistic is distributed χ^2 with one degree of freedom if only one parameter in the P matrix is allowed to vary, and is, as Garbade emphasizes, a conservative test.

9/It is interesting to note that the peak of the unexpected money coefficient coincides quite closely with the apparent end of the distorting effect of the NOW account introduction. For example, the growth rates of M1 averaged 13.8 percent during the first four months of 1981 compared to a 6.4 percent rate for the shift-adjusted measure. During the next four month period, however, M1 decreased at a 0.4 percent rate and shift adjusted decreased at a 1.0 percent rate. These figures indicate that the distorting effect of the shift of funds into the new NOW accounts abated by May, the time when the coefficient on unexpected money begins to decline.

10/The year 1983 was not split in two since data were available only through October.

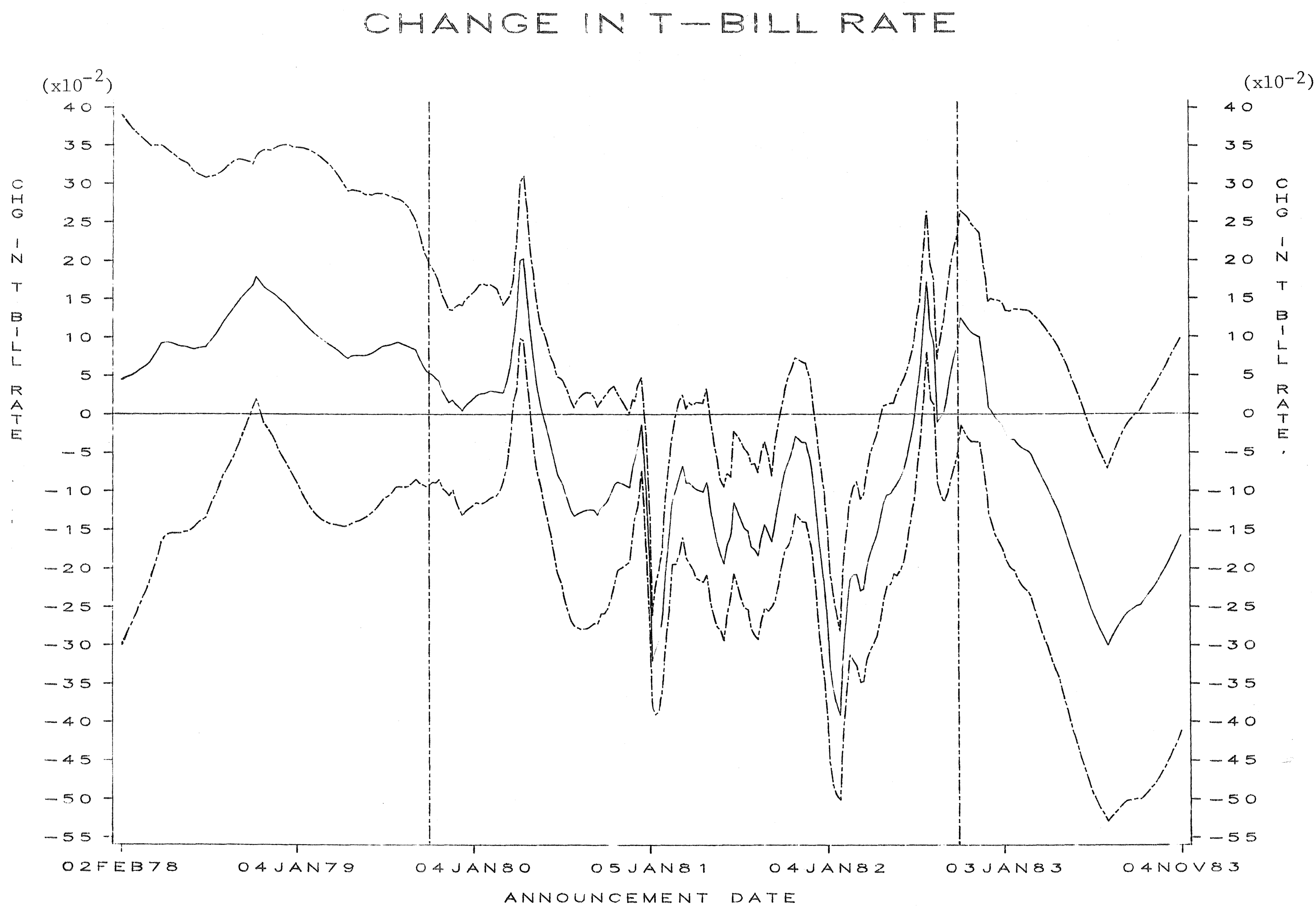
11/Benchmark revisions generally occur during the first and middle parts of the year. Social security weeks occur when the third day of the month falls on a weekend, or on a holiday that also happens to be a Friday or a Monday. Because many social security recipients receive direct deposits and these deposits are made on the third day of the month, this quirk in the payment timing artificially enlarges the announced money supply figure for that week. For evidence on this phenomenon and its effects, see Hafer (1984) and Clark, Joines and Phillips (1985).

Table 1
Stabilogram Test Results

Period	Estimated Coefficients[1]			
	Constant	EM	UM	TBCH
1/5/78 - 6/29/78	-0.006	0.004	0.010	0.014
6/29/78 - 1/1/79	0.003	-0.003	-0.004	0.217
1/4/79 - 6/28/79	0.016	-0.003	0.016	0.088
6/28/79 - 1/1/80	-0.005	-0.006	0.043*	0.015
1/4/80 - 6/27/80	-0.015	0.048	0.012	0.098
6/27/80 - 1/1/81	0.012	-0.040	0.050*	-0.030
1/5/81 - 6/26/81	-0.040	-0.119*	0.084*	-0.189*
6/26/81 - 1/1/82	-0.019	-0.006	0.066*	-0.121
1/4/82 - 6/25/82	0.002	-0.027	0.059*	-0.146*
6/25/82 - 1/1/83	-0.038	-0.001	0.055*	0.009
1/3/83 - 10/28/83	0.026	-0.017	0.035*	-0.160
F-test[2]	0.56 (0.85)	2.31 (0.01)	4.13 (0.00)	1.91 (0.04)

Notes: 1/ * denotes significance at the 5 percent level.

2/ F-test pertains to testing equality of coefficients across subperiods. Significance levels in parentheses.



VERTICAL LINES REPRESENT
OCT. 4, 1979 & OCT. 1, 1982

FIGURE 1

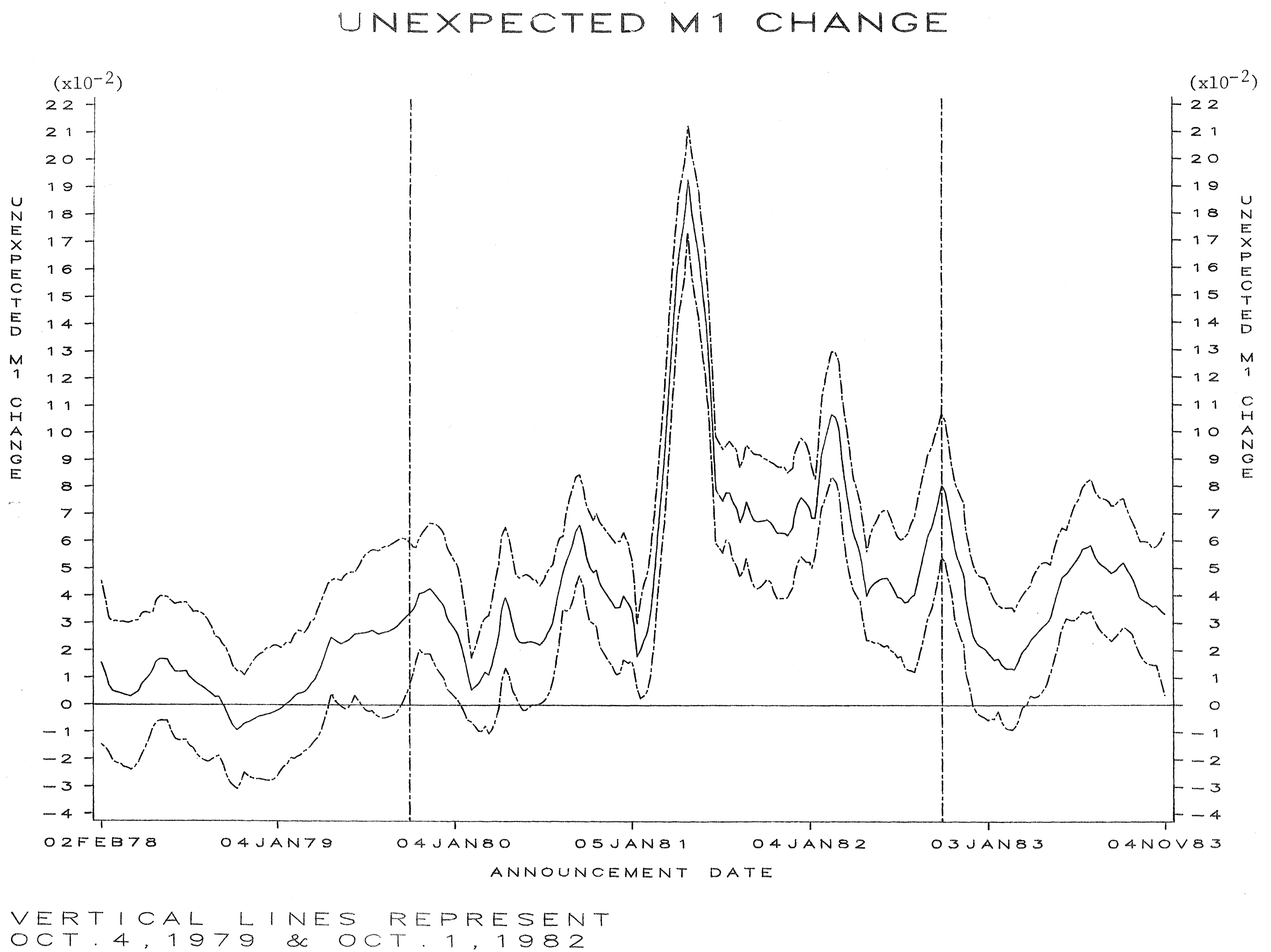

UNEXPECTED M1 CHANGE
(x10-2)
UNEXPECTED M1 CHANGE
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
02FEB78
04JAN79
04JAN80
05JAN81
04JAN82
03JAN83
04NOV83
ANNOUNCEMENT DATE
VERTICAL LINES REPRESENT
OCT. 4, 1979 & OCT. 1, 1982

FIGURE 2

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