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Abstract

In October of 1979, the U.S. Federal Reserve Board undertook a major, unprecedented change in operating procedure. This policy was formally abandoned on October 5, 1982. During the 1979–1982 period, bond yields across the term structure became much more volatile, and week-to-week changes in yields were strongly correlated with unexpected changes in the money supply. This paper reopens investigation of 1979–1982 episode by studying the relationship between monetary policy and short term interest rates, specifically the U.S. treasury bill market from 1 to 26 weeks. The objectives of the paper are twofold: first, to pull together a picture of this interval, laying out "stylized facts" that any successful explanation must address. Second, the paper investigates whether the financial market volatility during 1979–1982 can be understood in terms of Bayesian learning by financial market participants about an announced one-time shift in Federal Reserve policy. The results of the paper suggest that learning was not an important feature of the 1979–1982 period.

I. INTRODUCTION

In October of 1979, the U.S. Federal Reserve Board undertook a major, unprecedented change in its operating procedures. The Fed announced that it was switching from a policy under which nominal interest rates were the primary policy instrument to a policy of targeting the money stock using nonborrowed reserves as the policy instrument. This policy was formally abandoned on October 5, 1982 when the Fed announced that it would henceforth pay less attention to hitting particular money supply targets. Under the new operating procedure in the 1979–1982 period, the volatility of both long and short term interest rates increased dramatically, while the volatility of the money supply increased only slightly. The top panel of Figure 1 plots the week-to-week change in the yield to maturity for a thirteen week T-bill, and the bottom panel plots the weekly growth rate of the M1 measure of the money supply. Vertical bars in both plots mark the beginning and end of the 1979–1982 period. The increase in volatility of the T-bill yield in the 1979–1982 period is quite evident.

During the 1979–1982 period, changes in bond yields were strongly correlated with unexpected changes in the money supply. A large body of research has analyzed the response of asset markets during this period to the Fed's weekly announcements of the money supply statistics. While most of this research has focused on the reaction of bond prices or interest rates to unexpected changes in the money supply, researchers have also studied the response of foreign exchange markets and stock markets to the money supply announcements. The key stylized facts for the 1979–1982 period that this body of literature documents and attempts to explain are the following: (i) the change in interest rates from just before to just after the announcement is strongly positively correlated with the unexpected component of the announced change in the money supply; (ii) the response of short-term interest rates is as strong as the response of long-term interest rates; (iii) in foreign exchange markets, the dollar tended to appreciate with unexpected increases in the money stock, and (iv) stock market indexes tended to decline with unexpected increases in money. Despite the wealth of research on this episode, the volatility of interest rates during this period and the response of asset markets to money announcements are still largely unexplained phenomena.[1]

Because of the failure of any single model to explain all of the key stylized facts, several authors have hypothesized that uncertainty about current and future Fed policy played a key role in the 1979-1982 episode. Cornell (1983a), for example, states that

> Of the hypotheses considered, the one most consistent with the dramatic reaction of long-term rates to money supply announcements is that the Fed's stated change in operating procedure had a larger impact on the market than was previously realized. It is hypothesized that in response to the Fed's statement, market participants concluded that the rules under which monetary policy is conducted could no longer considered constant. As a result, weekly money supply announcements are analyzed with the goal of determining whether another change in the rules is possible. This shift in thinking, in turn, has a markedly destabilizing impact on long-run inflationary expectations.[2]

Understanding the response of asset markets to "news" in a setting where individuals are uncertain about the form of policy requires that we modify our models to reflect this uncertainty, and think seriously about the possibility that learning was an important feature of the 1979–1982 episode. Several researchers have reported features of this episode that can be interpreted as evidence that learning was potentially important. Lewis (1988), for example, finds that forward markets in foreign exchange systematically underpredicted the strength of the dollar over the 1979–1982 period. She formulates and estimates a model in which individuals are learning about a key parameter in the money demand equation, and finds that the learning model can explain about half of the variance in the forward market forecast error. Loeys (1985) found that the amplitude of the interest rate response to money supply announcements was highest immediately after the change in policy and varied substantially over the 1979–82 period. Hafer (1983) found that the expectation errors in money supply forecasts were contemporaneously correlated with observable variables such as consumer and industrial loans, demand deposits, and the adjusted base—something that should not be the case if expectations are formed rationally and if agents know the correct macroeconomic model. Clarida and Friedman (1984) find that interest rates in the 1979–1982 period were "too high" to be explained by unconstrained vector autoregressions estimated over the preceding period.

The time–varying response of asset markets to a surprises in M1 and the evidence of "irrationality" of expectations formation suggests that the class of linear rational expectations models with known parameters cannot explain the U.S. bond market in the 1979–82 period. In the classic rational expectations model, it is assumed that agents have enough information about the structure of the economy to forecast relevant economic variables "rationally" in the sense of Muth (1961). This assumption is a reasonable one if the economic environment—including government policy—has been in place long enough for agents to have learned its essential operating characteristics. Few would argue, however, that the rational expectations hypothesis in this form is necessarily an appropriate assumption when there has recently been a major change in the economic environment. In the context of the 1979 change in Fed operating procedure, the fact that the nonborrowed reserves targeting procedure was without precedent led to uncertainty about the money/interest rate link in the new environment. In addition, there was uncertainty about the strength of the Fed's commitment to announced money supply growth rates and the likelihood of sticking to these targets in the face of certain types of shocks.

This paper explores the idea that the time-varying response of interest rates to money announcements in the 1979–1982 period was due to learning behavior on the part of market participants.[3] The appeal of a learning model lies in its potential ability to explain short-run irrationality of forecasts and "excessive" volatility in the response of asset markets to Fed announcements. The chief argument against learning models is the view that, by introducing additional parameters in the form of parameterized prior distributions, the researcher allows himself sufficient freedom to explain any observed behavior. But, although parameters of prior distributions are not directly observable, within a broad class of prior distributions Bayesian learning models do place testable restrictions on observed time series. The main methodological point of the paper is that learning is a testable hypothesis. The Bayesian learning model restricts the time series properties of coefficient estimates and expectation errors, thus deviations from full-information rational expectations and market efficiency are not necessarily evidence of Bayesian learning. An implication of Bayesian learning models is that the response to shocks is time-varying in nature; the response is largest in the initial stages of the new policy, when uncertainty is highest.

With learning, the response of financial markets to "news" about the money supply process should decrease over time in a specific way. Since the policy announced in 1979 was in effect for only three years[4] and since the volatility of the money stock increased somewhat over this period, the question of whether the learning effect was important cannot be answered by a mere glance at the data. Yet it is important to determine whether the volatility of interest rates can potentially be explained by learning about the new policy, since an affirmative answer has important implications for the long-run effect of money stock targeting. If learning was important, it would be inappropriate to read the 1979-82 experience as demonstrating that money stock targeting leads, in the long run, to highly volatile interest rates.

Previous research

In two recent papers, Cornell (1983a,b) summarizes a large body of research on the "money announcements puzzle." Four distinct theories have emerged which attempt to explain some or all of the stylized facts laid out above. Briefly, these theories are as follows. The <u>expected inflation hypothesis</u> explains the rise in bond yields in response to money innovations as reflecting expectations of higher future monetary growth and hence higher expected inflation, which is incorporated in bond yields via the Fisher equation. The <u>policy anticipations hypothesis</u> views an unexpected rise in the money supply as signaling future tightening of the money supply as the

Fed attempts to keep money supply growth within the target bands. The result is a rise in expected future real interest rates (as a shifting LM curve moves up the IS curve), leading to a higher current real (and nominal) interest rate. The real activity theory begins from the supposition that money demand depends on expected future levels of real activity. The announcement of the money supply provides individuals with new information about expected levels of future real activity. For example, if the money supply announcement is higher than anticipated, individuals learn that current money demand is higher than anticipated, which causes them to revise upward their forecasts of future real output. The real interest rate must therefore rise to clear current markets in consumption and investment. Furthermore, current money demand increases, leading to an increase in nominal interest rates. The fourth main hypothesis is the risk premium hypothesis. Under this hypothesis, the positive correlation between interest rates and innovations in the money supply reflects the fact that interest rate risk increases when the Fed exceeds its target bands for the money supply. This is so because, when the Fed is near or outside its target bands, it must either take action to bring the money supply back inside the bands, or alter its policy in some other way. Uncertainty about future Fed policy, then, is the source of the increased risk.

In related work, Mascaro and Meltzer (1983) seek to explain the simultaneous increase in the level of the average real rate, and the increase in the variability of M1 and nominal interest rates. Their explanation hinges on the idea that increased risk in an asset causes substitution across assets. Specifically, Mascaro and Meltzer hypothesize that increased variability of monetary growth and velocity increased the risk faced by nominal bond holders, which is reflected in an increase in the variability of bond yields and in their average rate of return. In regressions of the change in interest rates on measures of variability, Mascaro and Meltzer conclude that variability in money helps explain the post-1979 variability in interest rates. They conclude that the change in operating procedure pushed the economy to a "less stable position."[5] Huizinga and Mishkin (1986) reexamine this hypothesis in a slightly different form. In regressions of ex ante real rates on monetary variance, they find no effect of the variability of money on ex ante real rates, in contrast to the Mascaro/Meltzer results. Huizinga and Mishkin conclude that there is "little evidence supporting the importance of uncertainty in the recent unusual behavior of real rates."[6]

In a paper examining commodity own rates of return, Cornell and French (1986) find that nearly all of the movement in one and three month interest rates in response to money supply innovations reflect changes in ex ante inflation, with little or no effect on real rates. For longer horizons (six to twelve months), Cornell and French find that both ex ante inflation and real interest rates respond positively to innovations in the money supply. Cornell and French's measure of the ex ante inflation rate includes both expected inflation and the asset's risk premium. Thus their results do not allow us to determine whether money affects interest rates via the expected inflation channel or via its effect on the instrument's risk premium.

While each of the proposed theories explains some portion of the 1979-1982 experience, none of the theories developed to date has provided a comprehensive explanation for the "money announcements puzzle." Specifically, none of the theories developed to date can explain why interest rates should react differently over time to unexpected changes in money of a given size. The aim of the present paper is to investigate the extent to which learning on the part of market participants helps to explain time-variation in the response of interest rates to money announcements.

The paper is organized as follows. Section II presents a simple model of money and interest rates. Within the context of this model, we explore the implications of learning behavior for a time-varying response of interest rates to innovations in the money supply. Section III is the first of two empirical sections. This section begins with a summary of the data set used in this paper; it is substantially different from data sets used in other contributions to the "money announcements" literature. Next, we briefly review the expectations theory of the term structure and the methodology used by Plosser (1982, 1987) to examine the effects on asset yields of innovations to policy variables. Using this methodology, we examine the differences across policy regimes of the time series behavior of the excess return on T-bills.

Section IV is the second empirical section of the paper. In this section, we examine the relationship between unexpected changes in the money supply and excess returns on Treasury bills.[7] This is accomplished in two stages. First, we show that week-to-week changes in yields to maturity are positively correlated with the unexpected component of the money announcement in the 1979-1982 period. Next, we ask whether unexpected changes in money is significantly related to revisions in expected future interest rates, and whether this relationship is stable across the three time periods under consideration. Finally, we provide a test of a generalization of the learning model of Section II. That model implies that a linear function of the agents' posterior estimates of the parameters of the money supply function should help explain the response of interest rates to money supply shocks. Section V concludes with a summary of the paper's main results and suggestions for future research.

II. A MODEL OF MONEY AND INTEREST RATES WITH LEARNING

The time-varying response of interest rates to money supply announcements can potentially be explained by a model in which there has been an announced change in a policy regime, and in which agents are uncertain about the nature of the change that has taken place.[8] Since the Fed cannot credibly commit itself to following a new policy, private agents can only discover the nature of the policy by observing realizations of the new money supply process. During the period in which agents are learning about the new policy parameters, inflation and interest rates will be correlated with unexpected changes in the money supply. Furthermore, the magnitude of the response will be highest in the initial stages of the new policy, and will decrease over time. Thus there will be an initial period in which interest rates will appear "excessively volatile" relative to the predictions of a rational expectations in which agents know the relevant policy parameters.

A Basic Monetary Model

The specific model developed here is a variant of Cagan's (1956) classic model of money demand and price level dynamics. Private agents' demand for money is assumed to be of the form (all variables are in logs):[9]

$$m_t - p_t = \alpha_o + \alpha_1 y_t - \alpha_2 E_t(p_{t+1} - p_t) \qquad (1)$$

where m_t is the outstanding stock of money (M1) at time t, p_t is the period t price level, y_t is period t real income, and v_t is period t shock to money demand. Money supply rules (or policies) are of the form:

$$m_t = A(L)m_{t-1} + B(L)X_t + \epsilon_t \tag{2}$$

where A(L), B(L) are polynomials in the lag operator, X_t is a vector of economic variables observable in period t, and ϵ_t is an error term, interpretable as due to imperfect monetary control. Equation (2) is a typical feedback rule for the money supply. For the 1977–1983 period, the M1 measure of the money supply process is well-described by the class of constant-growth rate money supply rules, although with different values of θ and σ^2 in different subperiods:

$$m_t = \theta + m_{t-1} + \epsilon_t \tag{3}$$

where θ is the "target" average rate of growth of the money supply, and ϵ_t is a normally-distributed disturbance term with mean zero and variance σ^2. Different "policies" in this context means different government choices of θ and σ^2 (again, σ^2 can be interpreted as the degree of monetary control achieved by the Fed under the chosen operating procedure.) Finally, suppose that real income, y_t, follows a first-order autoregressive process:

$$y_t = \rho y_{t-1} + \xi_t \tag{4}$$

Setting money supply equal to money demand and solving for p_t, we have the following expression for the equilibrium path of prices:

$$p_t = [1+\alpha_2]^{-1}[\alpha_o + m_t - \alpha_1 y_t + \alpha_2 E_t p_{t+1} - \epsilon_t] \tag{5}$$

If agents are assumed to know the values of θ and σ^2, then the model can be solved to yield:

$$p_t = (-\alpha_o+\alpha_2\theta) + m_t - \left[\frac{\alpha_1}{1+\alpha_2(1-\rho)}\right] y_t \ . \tag{6}$$

Expected inflation is given by:

$$\pi^e_{t+1} = E_t p_{t+1} - p_t = \theta + \left[\frac{\alpha_1(1-\rho)}{1+\alpha_2(1-\rho)}\right] y_t \tag{7}$$

and the actual inflation rate is:

$$\pi_{t+1} = p_{t+1}-p_t = \theta + \left[\frac{\alpha_1(1-\rho)}{1+\alpha_2(1-\rho)}\right] y_t + \left\{ \left[\frac{-\alpha_1}{1+\alpha_2(1-\rho)}\right] \xi_{t+1} + \epsilon_{t+1}\right\} \tag{8}$$

The term in curly brackets is the expectation error, reflecting unexpected movements in inflation due to forecast errors associated with output, money demand, and money supply. When the money supply follows a random walk, this model predicts that actual inflation is correlated with unexpected movements in the money supply, but that expected future inflation is not. This is because expected inflation for all future dates is always equal to θ, no matter what the current realization of the money stock growth rate might be. This in turn implies that the expected inflation component of nominal interest rates should not respond to the unexpected component of the change in the money supply.

The basic model with learning

Now, consider the time path of prices in the case where agents do not know the parameters of the monetary policy rule: θ and σ^2. This is the situation faced by agents at the beginning of a new "policy regime," such as the one that began in October of 1979. Although the Fed had announced target bands for θ, individuals continued to face uncertainty about the truth of these announcements and about the Fed's commitment to carry out the plan as announced.

To give the learning hypothesis testable content, suppose that agents in the economy act as Bayesian decisionmakers and use their priors and past data on m_t to form posterior estimates of θ and σ^2. Let $\hat{\theta}_t$ denote the posterior estimate of θ at date t, and let t=1 denote the date on which the policy shift took place. The posterior estimate combines agents' priors with sample information. The key characteristic of Bayesian learning is that a given observation affects agents' estimates of the policy parameter more the earlier it occurs. Later observations cause smaller revisions in agents' beliefs about the policy parameter since, by that time, agents have observed many realizations of the policy variable and so have a great deal of information about the true value of the parameter. If agents' prior distributions are diffuse, then only sample data is used in forming posterior estimates of the parameter θ. Since money follows a random walk, there is a particularly simple form for this posterior estimate: $\hat{\theta}_t$ is just the average growth rate of money from the beginning of the sample until date t. That is, (letting period 1 denote the first period of the new regime),

$$\hat{\theta}_t = (1/t) \sum_{j=1}^{t} (m_j - m_{j-1}) = \theta + (1/t) \sum_{j=1}^{t} \epsilon_j \quad . \qquad (9)$$

Equation (9) shows the effect of unexpected changes in the money supply (ϵ_t) on agents' beliefs about the policy parameter θ. Early in the reform period (small values of t) these unexpected changes have a large effect on $\hat{\theta}_t$. If, on the other hand, the policy regime has been in place a long time the effect of a single ϵ_t on agents' beliefs about θ will be negligible.

To see how this effect operates in practice, Figure 2 plots $\hat{\theta}_t$ using the M1 definition of the money supply computed over the 1979–1982 period, under the assumption that agents had a diffuse prior. Figure 3 plots the weekly growth rates in M1 over the same period. Despite the fact that the volatility of the weekly growth rate is roughly constant over the 1979–1982 period, the posterior mean for θ is much more volatile in the early part of the period. This essential time variation in the effects of unexpected money on agents' beliefs about future monetary growth rates will induce time variation in the response of interest rates to monetary shocks, as is demonstrated below.

Following a Bayesian learning procedure, agents forecast future values of m_t according to:

$$E_t m_{t+k} = k\hat{\theta}_t + m_t \quad . \tag{10}$$

With learning, the solution for p_t is

$$p_t = (-\alpha_o + \alpha_2\hat{\theta}_t) + m_t - \left[\frac{\alpha_1}{1+\alpha_2(1-\rho)}\right] y_t \tag{11}$$

Expected inflation is given by

$$\pi^e_{t+1} = E_t p_{t+1} - p_t = \hat{\theta}_t + \left[\frac{\alpha_1(1-\rho)}{1+\alpha_2(1-\rho)}\right] y_t \tag{12}$$

and actual inflation is equal to

$$\pi_{t+1} = \theta + \alpha_2(\hat{\theta}_{t+1}-\hat{\theta}_t) + \left[\frac{\alpha_1(1-\rho)}{1+\alpha_2(1-\rho)}\right] y_t + \left\{\left[\frac{-\alpha_1}{1+\alpha_2(1-\rho)}\right] \xi_{t+1} + \epsilon_{t+1}\right\} \tag{13}$$

This example shows the effect of agents' uncertainty about the policy parameters on the evolution of prices and expectations of inflation. The effect on current and expected future prices of a particular realization of ϵ_t depends on the date t. Unexpected changes in money (ϵ_t) affect prices through two channels: First, the "quantity-theory" channel implies that the price level is proportionate to the current money supply, holding constant agents' beliefs about the long-run (or "target") monetary growth. The second channel—and the one that is affected by the date of a particular money supply realization—is the channel by which current prices depend on expectations of long-run inflation. The effect of a particular realization of ϵ_t on π_t depends on the date t. In the early stages of a reform, while agents are quite uncertain about the underlying policy process, a large realization of the ϵ_t will cause large upward revisions in agents' beliefs about the government's target monetary growth rate and, hence, will cause large upward revisions in expectations of inflation. By contrast, the same large realization of ϵ, if it occurs well into the reform period, and if it follows a period of low average growth rates, would be viewed as the realization of a low-probability event, and would not induce large revisions in agents' expectations of future inflation. In the limit (as t approaches infinity) uncertainty about the policy disappears as $\hat{\theta}_t$ converges to the true θ, and money affects prices only through the "quantity theory" channel (as in equation (7)).

Thus with uncertainty about policy, the effect of realizations of the policy variable on expectations cannot be expressed as a function that is independent of time. A policy implication is the following: if a government announces a reduced rate of monetary expansion in an effort to reduce inflation, close adherence to the new target is much more important for the reduction of inflation during the early stages of the new regime than in the later stages.[10]

Learning, interest rates and inflation

The fact that agents form and update their beliefs in this manner has strong implications for the effect of a given change in the money supply on expectations of inflation and hence on nominal interest rates. Specifically, that model predicts that the effect on inflationary expectations of a given realization of the monetary growth rate depends on the date at which it is realized. Suppose that the nominal interest rate, i_t, depends on expected inflation, π^e_t, and on a real rate, r_t, assumed invariant to expected inflation:

$$i_t = r_t + \pi^e_t \tag{14}$$

Suppose also that agents are learning about monetary policy. In the context of the model above, nominal interest rates under learning are given by

$$i_t = r_t + \hat{\theta}_t \tag{15}$$

This theory thus implies that the amplitude of the response of financial markets to news about the money supply should be largest in the initial stages of a reform, i.e., when the largest revisions occur in agents expectations about θ. It implies in particular that one cannot infer that a policy of targeting the money supply necessarily leads to long-run volatility of interest rates, even though such volatility may be found immediately following a shift in policy.

Looking ahead to the empirical work of the paper, we see from equation (15) that $\hat{\theta}_t$—private agents' posterior beliefs about the target rate of growth of the money supply—should help explain nominal interest rates. Furthermore, it implies that nominal interest rates should become more volatile when there is a perceived change in policy regime, and that this volatility should be greatest in the early stages of the new regime. This implication of the learning model is testable; we undertake some tests of this theory in Section IV below.

III. THE BEHAVIOR OF INTEREST RATES

This section examines the behavior of interest rates over the 1977–1983 period. The focus is on documenting the differences in the time series properties of nominal rates over the 1979–1982 period.[11] The section begins with a description of the data set used. The second subsection briefly reviews the expectations theory of the term structure. The final subsection documents the differences across policy regimes in the time series behavior of interest rates.

The Data

The data set consists of weekly observations on Treasury bill yields for bills with one week to maturity through 25 weeks to maturity (inclusive), together with weekly data on announced changes in M1 and the expected change in M1 according to a survey conducted by Money Market Services, Inc. The sample period runs from January 1978 through December 1983.

We have chosen to focus on 1 through 25 week Treasury bill returns since there will always be bill whose term to maturity matches the sample interval. Thus we can compute, following Roll (1970), an implicit forward rate applicable for 1 through 24 weeks ahead for each week in the sample period. Hence, when we study expectational models of the term structure, there are no econometric problems with forward rates (i) containing multiperiod forecasting errors, or (ii) being subject to an approximation error that may arise when not using pure discount bonds. The data set was constructed using the method described by Roll (1970).[13] The Treasury bill data was primarily collected from the Wall Street Journal. Treasury bills mature on Thursdays, and the last trade date for maturing bills is two working days before the maturity date—usually a Tuesday. Therefore, in weeks without holidays, bid and asked quotes were collected for the Tuesday close. For weeks in which holidays fell on Tuesday or Wednesday, Monday quotes were used. For weeks in which holidays fell on Thursdays, the Tuesday quotes were used. As Roll (1970) notes, this procedure induces measurement error into the sample, but Roll found no effect of this measurement error and we follow his procedure in including these observations in the sample. The data was checked for errors using the tests outlined by Roll (1970, pages 51–52).[13] For each bill, the average of the bid and asked rates were used to computed the bill's price and its continuously compounded, annualized yields to maturity (in percentage points).

To summarize: the data set consists of Treasury bill yields for bills from one through 25 weeks to maturity. Because there is a T-bill which matures each week, it will be possible to use the expectations theory of the term structure to compute implied forward rates for the entire 25 week term. We will therefore be able to investigate the effects of money announcements on each forward rate, isolating effects occurring across the term structure. Thus this new data set has the potential to provide new insights into the 1979–1982 period.

The money supply data is the standard data used in the money announcements literature. Specifically, the data set consists of the Fed H.6 release of the M1 (or M1B after February 1980) money supply figure for the week ending eight or nine days earlier. (Before February 1980, the money supply figure was released on Thursdays; subsequently it was released on Friday.) The expected change in the money supply is from the survey conducted by Money Market Services, Inc. of San Francisco on Tuesday mornings throughout the sample period. This is the measure of expected changes in the money supply previously used by a large number of researchers.

The announced change in the money supply equals the revised money supply figure for the previous week (i.e., the one ending seventeen days before the announcement date) plus the Fed's estimate of the change from that date to the subsequent week. Let AC_t denote the date t announcement of the change in the money supply (for the week ending ten days earlier), and let EC_t denote the market expectation of the announcement. Let $M1_t$ be the announced level of the money supply, and let $RM1_t$ denote the revised figure for $M1_t$. Then $AC_t = M1_t - RM1_{t-1}$. In constructing the unexpected change in the money supply, we need to address the issue of whether the revision in $M1_{t-1}$ is predictable by the market. In the majority of the money announcements literature, unexpected changes in money are measured as $AC_t - EC_t$. This procedure is valid if the revision in the money supply figure for the previous week is perfectly predicted by the market. And, in fact, a recent paper by Mankiw, Runkle and Shapiro (1984) suggests that at least part of the revision in last period's M1 figure was predictable.

But if revision in last period's M1 figure is not perfectly anticipated by the market, the usual measure of unanticipated changes in M1 is incorrect. Let $REV_{t-1} = RM1_{t-1} - M1_{t-1}$ denote the revision in the M1 figure for period t. If the entire revision for period t-1 were completely unpredictable, then the unexpected component of the announced change in the money supply would be given by $AC_t - EC_t + REV_{t-1}$. In the empirical work below, both measures of unexpected changes in money were used; both measures gave very similar answers throughout. Consequently, we report results only for the more conventional measure, AC-EC. Specifically, unexpected money is computed as a percentage of the previous week's unrevised money supply figure: $UM_t = (AC_t - EC_t)/M1_{t-1}$.

The expectations theory of the term structure

The basic expectations theory of the term structure is described briefly below: see Roll (1970), Shiller (1972), and Modigliani and Shiller (1973) for more detailed discussion of this model.

The price of a pure discount bond with n periods to maturity is given by:

$$P_{nt} = \exp(-nR_{nt})$$

where R_{nt} denotes the continuously compounded n-period yield to maturity. The holding period return for this n-period bond from date t to date t+1 is given by:

$$\begin{aligned} H_{n,t+1} &= \ln(P_{n-1,t+1}/P_{nt}) \\ &= nR_{nt} - (n-1)R_{n-1,t+1} \quad . \end{aligned} \tag{16}$$

The expectations theory of the term structure is then given by the relationship:

$$R_{nt} = (1/n)(R_{1t} + E_tR_{1,t+1} + E_tR_{1,t+2} + \dots + E_tR_{1,t+n-1}) + \psi_{nt} \qquad (17)$$

where ψ_{nt} is interpreted as a liquidity premium (or term premium) with unspecified time series properties. The holding period return may then be expressed as:

$$H_{n,t+1} = R_{1t} - (R_{1,t+1} - E_tR_{1,t+1}) - (E_{t+1}R_{1,t+2} - E_tR_{1,t+2}) - \dots$$
$$- (E_{t+1}R_{1,t+n-1} - E_tR_{1,t+n-1}) + \phi_{nt} \qquad (18)$$

where $\phi_{nt} = \psi_{nt} - \psi_{n-1,t+1}$, and which Plosser terms a "marginal liquidity premium." The holding period return is the sum of the one-period sure return, R_{1t}, plus the sum of revisions in expected future one-period rates, plus the marginal liquidity premium. We denote by $F_{n,t+1}$ the revision from time t to time t+1 in expectations of the rate for a one-week bill beginning in period t+n-1 (and maturing in period t+n):

$$F_{n,t+1} = (E_{t+1}R_{1,t+n-1} - E_tR_{1,t+n-1}) \quad .$$

The empirical work will focus on these forward rate revisions instead of holding period yields, because they more easily allow us to identify effects that differ across the term structure.

Returning for the moment to holding period yields, however, we find that the expected one-period holding period return is:

$$E_tH_{n,t+1} = R_{1t} + \phi_{nt} \quad , \qquad (19)$$

and the excess holding period return is:

$$H_{n,t+1} - E_tH_{n,t+1} = \epsilon_{n,t+1} \qquad (20)$$
$$= -(R_{1,t+1} - E_tR_{1,t+1}) - \dots - (E_{t+1}R_{1,t+n-1} - E_tR_{1,t+n-1}) .$$

Market efficiency or rationality together with the expectations theory of the term structure implies that this expectation error (or abnormal return) should be a zero mean, serially uncorrelated random variable. Further, it should be uncorrelated with any variable in the period t information set.

Time series properties of the data across regimes

Before proceeding to investigating the relationship between money announcements and T-bill yields, we first examine the statistical properties of the yields alone. Recall that the data set consists of weekly data on yields for T-bills with 1 to 25 weeks to maturity inclusive, for the period January 1977 through December 1983. Under the assumption that marginal liquidity premia, ϕ_{nt}, are constant over time, excess returns defined as $[H_{n,t+1}-R_{1t}]$ should be zero mean, serially uncorrelated random variables.

Table 1 presents summary statistics for the return on one-week T-bill returns for the entire sample period. Because of the weekly sample interval, the holding period yield for the one-week bond is known at the beginning of the time period, since the holding period yield is identical to the bill's yield to maturity. Excess holding period returns for other bills are computed relative to the one-week bill.

Figure 4 plots the one-week return over the entire 1978-1983 sample period. The period has three subperiods of interest, with the middle subperiod being one focused on in studies of the money announcements puzzle. Specifically, the subperiods are defined as follows: Period I runs from 1/3/78-10/2/79, Period II runs from 10/9/79-9/28/82, and period III runs from 10/5/82-12/27/83. (October 9, 1979 and October 5, 1982 are marked by vertical lines on the graph.) Table 1 gives the mean, standard deviation, and autocorrelations of the one-week bill, by subperiod. Both the mean level of the one-week return and its standard deviation are substantially higher in the period between October 1979 and October 1982 than either before or afterward. In all three periods, the one-week return is highly serially correlated. This corroborates Plosser's (1982) results for quarterly data, as does the apparent nonstationarity of the return.

In his 1982 paper, Plosser found that excess returns, defined as $H_{n,t+1}-R_{1t}$, for bills and bonds with longer than one period to maturity had means insignificantly different from zero and were serially uncorrelated. In order to isolate differences across the term structure, we choose to examine the properties of the forward rate revisions, $F_{n,t+1}$, which comprise the excess return (see equation (17)), instead of studying the excess returns themselves. Table 2 gives means and standard deviations of these forward rate revisions. While the mean revisions are roughly of the same order of magnitude for all three periods, the standard deviations of these revisions are about three times higher in period II (the 10/9/79–9/28/82 period) than in periods I or III (i.e., the 1/3/78–10/2/79 period or the 10/5/82–12/27/83 period). Figure 5 plots F4, the forward rate revisions for the one week bill maturing in 4 weeks. The increased volatility in period II is quite evident; similar patterns are observed for revisions in other forward rates. Table 3 gives the sample autocorrelations for the forward rate revisions, by subperiod. In all three subperiods, the vast majority of the autocorrelations are insignificantly different from zero.

The increased volatility in excess holding period yields and implied forward rates during the 1979–1982 period is broadly consistent with learning about a new, but unknown monetary policy. On the other hand, the volatility of excess returns and forward rate revisions appears fairly uniform throughout this period, which appears inconsistent with the predictions of the simple learning model. In the next section, we investigate the relationship between money and interest rates during this period.

IV. LEARNING, MONEY ANNOUNCEMENTS, AND INTEREST RATES

This section investigates the effect of money supply announcements on weekly T-bill returns. The empirical methodology used is different from the one commonly employed in the money announcements literature. In that literature, the change in bond yields from just before the announcement to just after the announcement is regressed on the unexpected component of the money supply announcement. With the standard methodology, researchers have noted that the change in bond yields was strongly positively correlated with unexpected movements in the money supply during the 1979–1982 period.

This section begins by investigating the relationship between unexpected changes in money and revisions in expected future interest rates. The data set consisting of weekly observations on Treasury bill yields for bills with one week through 26 weeks to maturity. This data set allows us to investigate the effects of money announcements on bills of constant maturity. This allows us to isolate changes in bond yields that are not due to differences in term premia. Furthermore, the expectations theory of the term structure described in Section III was developed for pure discount bonds such as T-bills. This theory implies that excess holding period returns on these bills should be uncorrelated with information from earlier periods. We follow Plosser (1982, 1987) in investigating the relationship between revisions in holding period returns and implied one-period forward rates on the one hand, and macroeconomic variables on the other. Whereas Plosser investigates the effects of government financing decisions on T-bill and bond yields, we are interested in the effects of the money supply announcements on T-bill yields.

Time series properties of monetary variables

Tables 4 and 5 present summary statistics for the money supply and for expected, actual, and unexpected changes in money. Since the money supply in levels appears nonstationary, statistics for growth rates of the money supply are also given. As noted by other researchers, actual weekly changes in the money supply are slightly negatively serially correlated in all three subperiods under study. Expected changes in the money supply are less volatile than actual changes, which is consistent with rationality of expectations formation. Figure 6 plots the weekly growth rate in M1 over the three subperiods; the mean growth rate by subperiod is indicated by a horizontal line on the graph. In period II, the average M1 growth rate dropped slightly, and the volatility increased. But the change in the level and volatility of M1 in this period is not nearly as striking as the changes in level and volatility that occurred in interest rates. (Recall that the variance of forward rate revisions roughly tripled). In fact, it could reasonably be argued that, in terms of M1, there is not much evidence of a shift in Fed policy during this middle period.[14]

Since we use the Money Market Survey to measure expected changes in the money supply, we carry out some simple tests of the rationality of these forecasts. Table 6 presents regressions of announced changes on expected changes, by subperiod. In all three periods the coefficient on the expected change is insignificantly different from one. In all but the first period, the constant term is insignificantly different from zero. This has been traced to one outlier in the data, however, so we do not interpret this result as implying biasedness of expectations during this period.[15] Table 7 presents regressions of unexpected changes in money on a constant and one lag of the unexpected change. In all three periods, the coefficient on lagged unexpected money is insignificantly different from zero, and the constant is insignificantly different form zero in periods II and III. The constant is negative in period I; again, this is due to a single outlier. These simple tests of the rationality of the survey forecast of the expected change in the money suggest that forecasts were rational and unbiased during the 1979–1982 period. However, Hafer (1983) did find some variables which were public information at the time the forecasts were made, and which were correlated with forecast errors during the 1979–1982 period.

The standard money announcements procedure

In most studies of the effects of money announcements on bond markets, the change in bond yields is regressed on unexpected changes in money. In some studies, the expected change in the money supply is included as a regressor as well. The change in yields is typically measured over a short period: a few hours to a day at most. Since the present study uses bonds of constant maturity, changes in bond yields are measured over a week. This longer time interval could potentially mask the effects of the money announcements on the change in bond yields, as other shocks occurring during the week could also affect yields. Therefore, we begin our investigation the effects of money supply announcements on interest rates by verifying that, in our data set, we find a positive effect of unexpected changes in M1 on changes in bond yields. The analogue to the usual money announcements regression with this data set is:

$$\Delta R_{nt} = R_{n,t+1} - R_{nt} = \alpha_{0n} + \alpha_{1n}UM_t + \alpha_{2n}EC_t + \epsilon_{nt} \qquad (21)$$

where R_{nt} denotes the yield to maturity of an n week bond, UM_t denotes the unexpected component of the money supply announcement made in week t, and EC_t is the expected change in the money supply. Both UM_t and EC_t are computed as a percentage of the previous period's money stock. Table 8 summarizes the results of running this regression for each of the three sample periods. Our results are similar in character to those reported by other researchers. In period I, neither unexpected money nor expected money helps explain changes in bond yields. In period II, the October 1979–October 1982 period, there is a significant positive relationship between unexpected changes in M1 and the change in bond yields across the term structure. Further, the coefficient on unexpected money is roughly constant across the term structure, indicating that all interest rates moved by about the same amount in response to the money announcement. Also, the expected change in the money supply enters during this period with a negative coefficient. In period III, there is still evidence of a positive coefficient on unanticipated money, but the expected change is no longer significant. It is tempting to interpret the significant coefficient on the expected change in money during period II as evidence of learning or perhaps irrationality. However, it could also be due to the fact the expected money influences expected future real rates or risk premia.

The effects of money announcements on forward rate revisions

The next step in our investigation of the effects of money supply announcements on interest rates involves regressing the unexpected change in the money stock for a given week on the revision in forward rates for that week. While an alternative is to investigate the effects of unexpected changes in the money supply on excess holding period returns, which are made up of the forward rate revisions, we look at the forward rate revisions directly in order to more easily isolate potential differences occurring across the term structure. Specifically, we are looking for differences across the three time periods in the relationship between unexpected changes in money and excess returns on T-bills.[16]

The regressions that were run are of the following form:

$$F_{n,t+1} = \alpha_{0n} + \alpha_{1n}F_{n,t-1} + \alpha_{2n}F_{n,t-2} + \psi_{1n}UM_t + \psi_{2n}EC_t + \epsilon_{nt} \qquad (22)$$

where F_{nt} is the revision in the expected future one period rate beginning in n-1 periods, UM_t is the unexpected change in M1 in week t, and EC_t is the expected change, as reported by Money Market Services, Inc. Although the theory of Section II suggests that only unanticipated money should affect revisions in expected future inflation rates, the expected change in money could affect expected future real rates and risk premia. The expected change variable is included in equation (22) for this reason.

Table 9 presents coefficient estimates and standard errors by subperiod for equation (22). In period I, neither expected nor unexpected money has a significant effect on the forward rate revisions. In period II, unanticipated money generally carries a significantly positive coefficient. Looking across the 25-week term structure, we see that the effect on implied forward rates of unanticipated money is roughly constant across the term structure. In particular, the effect is not stronger for more distant forward rates, something that might be expected under the inflationary expectations theory since it takes time for innovations in money to be translated into inflation. In period II, the coefficient on expected changes in money is still generally negative, but is not significantly different from zero in most cases. This stands in contrast to the results obtained for changes in yields to maturity, in which the negative coefficient was typically significant. In period III, unexpected money continues to have a generally significant positive effect on forward rate revisions, although the magnitude of the effect is not as great as in period II. The effect across the term structure continues to be uniform, with the response at short horizons roughly the same as the response at longer horizons. The coefficient on the expected change variable is insignificantly different from zero in all but a few cases.

The time-varying response of implied forward rates to money announcements

In the previous section, revisions in implied forward rates were regressed on unexpected and expected changes in money, by subperiod. But regressions run by subperiod could mask learning effects that took place only in the weeks immediately following the change in operating procedure. Evidence of learning behavior would be found in a specific time-varying pattern in ψ_{1n}, the coefficients on UM_t. Specifically, if learning was important in the 1979–82 period, and if there was only one change in operating procedure during this period (one expected change and one actual change), then recursive estimates of ψ_{1n} should show high volatility beginning in 1979, with decreased volatility and convergence to a constant value of ψ_{1n} as agents become certain about the relevant policy parameter.

Therefore, to investigate whether learning was potentially an issue in the period immediately after October 1979, the recursive coefficient for unexpected money was calculated for equation (22), using two forward rate revisions: a relatively short one, F_4, and the longest one available, F_{25}. The recursive regression was run over the entire 1978–1983 period. Figure 7 plots the recursive coefficient on unexpected money; the 1979–1982 period is delineated by vertical lines. This plot shows that the recursive coefficients are quite volatile at the beginning of the sample period—something that is a standard property of recursive estimates. The important point is that the volatility of the recursive coefficient estimates does not increase very much at the beginning of period II (i.e., in October 1979.) The level and volatility of the coefficient estimates increases only in April and May 1980, a period that coincides with the imposition of the Carter credit controls. Thus the pattern observed in these recursive coefficients suggests that the simple learning model may not be a good explanation for the observed volatility of interest rates during the 1979–1982 period. However, this evidence is essentially informal in character. In the next, and last, part of this section, we undertake a formal test of the learning model of section II.

Testing the learning model of Section II

In Section II, we developed a simple model of money and interest rates which incorporated the potential for learning effects. In that model, unexpected changes in the money supply affected interest rates through two channels. The first channel is that by which an unexpected increase in money today causes an increase in expectations of future inflation, holding fixed agents' beliefs about the money supply process.[17] This channel is captured by a constant coefficient relating the innovation in money to revisions in forward rates. If money follows a random walk with drift, expected future inflation rates are unaffected by unexpected changes in the current money supply. Thus, in this case, unexpected changes in money should affect current and implied future interest rates only through effects on real rates and risk premia. The second channel is that by which an unexpected increase in money today causes agents to revise their beliefs about the money supply process being followed. This prompts a revision in expected future money supplies, and hence implies a revision in expected future inflation over and above that caused by the first channel. Most importantly, this second channel implies a time-varying relationship between money innovations and revisions in forward rates.

Returning to the simple model of Section II, recall that we derived the following relationship between nominal interest rates and the money supply, under the hypothesis that real rates were uncorrelated with expected inflation:

$$i_t = r_t + \hat{\theta}_t \qquad (23)$$

where $\hat{\theta}_t$ denotes the mean of agents' posterior p.d.f. for θ, the target rate of growth of the money supply. At this point, we are interested in deriving the implications of this simple learning model for the response of excess holding period returns and implied forward rates to unanticipated movements in the money stock. Toward this end, we split the one-period nominal interest rate , R_{1t} into a one-period real return, r_t, and the expected one-period inflation rate, π_t^e: $R_{1t}=r_t+\pi_t^e$. Then the forward rate revision for a one-period bond maturing in n periods becomes:

$$\begin{aligned} F_{n,t+1} &= (E_{t+1}R_{1,t+n-1}-E_tR_{1,t+n-1}) \\ &= (E_{t+1}r_{t+n-1}-E_tr_{t+n-1}) - (E_{t+1}\pi_{t+n-1}-E_t\pi_{t+n-1}) \qquad (24) \end{aligned}$$

If money growth follows a random walk, which appears to be the case, and if agents know the average growth rate, θ, with certainty, then expected future inflation rates always equal θ, and the revisions in expected future inflation rates are always zero. In this situation, the excess holding period return simply reflects revision in expected future real rates:

$$F_{n,t+1} = (E_{t+1}r_{t+n-1} - E_t r_{t+n-1}) \tag{25}$$

If, on the other hand, agents were learning about monetary policy in the Bayesian manner described in Section II, new realizations of the money supply process would induce revisions in their expectations of the target level of money supply growth, θ, and thus would induce revisions in future inflation rates. Within the model of Section II, the period t expectation of all future inflation rates is $\hat{\theta}_t$; i.e., $E_t\pi_{t+j} = \hat{\theta}_t$ for all $j \geq 1$. Thus (24) becomes:

$$F_{n,t+1} = (E_{t+1}r_{t+n-1} - E_t r_{t+n-1}) + (\hat{\theta}_t - \hat{\theta}_{t-1}) \tag{26}$$

Thus a testable implication of the learning model is that the change in the mean of the posterior distribution for θ should help explain excess holding period returns. Even if the simple model of Section II is incorrect in its assumption that money growth is translated immediately into increases in inflation, as long as increased money growth eventually causes inflation we would expect to see correlation between $\hat{\theta}_t - \hat{\theta}_{t-1}$ and excess holding period yields. Since we have not specified a model for the real rate process, we will not be able to distinguish whether any observed effects of money on nominal rates operate via the expected inflation channel stressed above, or whether the effects are coming through effects on expected future real rates.

To investigate this effect, the following regressions was run for each F_n over the 1979–1982 period:

$$F_{nt} = \alpha_{0n} + \alpha_{1n}F_{n,t-1} + \alpha_{2n}F_{n,t-2} + \gamma_n(\hat{\theta}_t - \hat{\theta}_{t-1}) + \psi_{1n}UM_t + \psi_{2n}EC_t + \epsilon_{nt} \tag{27}$$

The results of this regression are given in Table 10. The estimates of the ψ_{1n} and ψ_{2n} coefficients are roughly unchanged from Table 9. But here, the focus is on the coefficients γ_n. Recall that, if the model of Section II is correct, the value of γ_n should equal 1. Of course, in that model shocks to money were transmitted immediately to inflation, so it would be very surprising if γ_n were of the magnitude implied by that theory. However, only half the estimates of γ_n carry the correct sign.[18] Therefore, we interpret these tests as suggesting that learning of the form modeled in Section II was probably not an important feature of the 1979–1982 episode.

V. SUMMARY AND CONCLUSIONS

The October 1979 announcement of a change in Federal Reserve System operating policies was widely viewed as signaling a more fundamental change in its policy objectives. On a technical level, the Fed announced a movement from the use of an interest rate instrument, with associated short run targets involving bands for the federal funds rate, to a nonborrowed reserve instrument with explicit targets for the growth of monetary aggregates. The popular interpretation, however, was the Fed had become more monetarist, with an increased policy emphasis on the control of inflation rather than real activity.

The response in the financial markets to this announcement was dramatic: the weekly announcement of money supply statistics covering the reporting period two weeks earlier became major news. The intense market interest in the release of information during a period of higher and more volatile interest rates prompted Federal Reserve and academic economists, as well as in the popular press, to ask (i) whether the financial markets were overreacting to monetary data; and (ii) whether the new operating procedures were working to destabilize financial markets, either directly or by contributing to interest rate uncertainty. During the 1979–1982 period, there was a varying response of the financial markets to monetary information, which has been documented by Loeys (1985) and others. Ultimately, in October 1982, the Federal Reserve announced an end to nonborrowed reserve targeting. This decision was rationalized, at least in part, by the turbulence of the preceding interval.

This paper has reopened investigation of 1979–1982 episode by studying the relationship between monetary policy and short term interest rates, specifically the U.S. treasury bill market from 1 to 26 weeks. The objectives of the paper were twofold: first, to pull together a picture of this interval, laying out "stylized facts" that any successful explanation must address. Second, the paper investigates whether the financial market volatility during 1979–1982 can be understood in terms of Bayesian, learning by financial market participants about an announced one–time shift in Federal Reserve policy.

The key facts about the 1979–1982 period are as follows.

(i) The volatility of both short term and long term interest rates increased markedly.

(ii) Forecast errors—represented by forward rate revisions—became more volatile during the 1979–1982 period. The variance of forward rate revisions was about three times more volatile in this period relative to the preceding period.

(iii) Week to week monetary behavior did not change dramatically, either in terms of (a) the mean rate of growth of M1, (b) the variance of weekly M1 growth rates, or (c) the variance of weekly expectations error formed using the survey expectations compiled by Money Market Services.

(iv) Unexpected changes in the money supply were associated with largely permanent revisions in the levels of yields, in the sense that the effect was similar in magnitude across the term structure. The effect of unexpected money on yields was markedly larger in the 1979–1982 period than it was in either the prior or subsequent interval.

The examination of the learning hypothesis proceeded in several stages. First, a simple model of financial market response to monetary news was formulated under (i) the conventional rational expectations assumption that the parameters of the policy rule are known by agents; and (ii) under the alternative assumption that there is an announced policy shift of an uncertain form, which must be inferred from the monetary data that is observed subsequent to the announcement. A key feature of the alternative expectations scenario—in which agents act as Bayesian econometricians—is that monetary events will have a larger impact on expectations and, hence, on interest rates when they occur close to the policy shift. In prior work, Baxter (1985) found that this implication of a learning model had substantial explanatory power in interpreting the dynamics of two dramatic South American monetary and fiscal reforms. However, in the 1979–1982 episode, revisions in the Bayesian estimate of the mean long run monetary growth rate provide relatively little explanatory power for variation in the short end of the term structure of interest rates. More informal evidence of learning behavior was sought in particular patterns of time-variation in (i) the volatility of forward rate revisions, and (ii) recursive estimates of the coefficient linking unexpected changes in money with forward rate revisions.

Based on the evidence presented in this paper, we conclude that a simple Bayesian learning model cannot explain the key stylized facts of the

1979–1982 period. Nevertheless, learning models are potentially important tools for understanding episodes involving changes in regimes, since these models place testable restrictions on economic time series. In the case of the 1979–1982 episode, however, the observed pattern of interest rates and money announcements is inconsistent with the learning model presented in this paper.

Despite the failure of the simple learning model to explain the 1979–1982 period, we share the opinion of Cornell (1983a) and others that uncertainty about current and future Fed policy played a key role during this period. The simple fact that the Fed continued to follow a random walk policy for setting M1, with its attendant "base drift," meant that future values of the money supply were much less predictable than they would have been under a policy of sticking to a fixed, long run average growth rate of money.

In light of the results of this paper, two avenues seem worthy of future research. The first approach would relax the assumption made in this paper that there was only one switch in Fed policy during the period. The second approach would recognize that there are several potential policies that the Fed could follow in the future, and would therefore model explicitly the process by which the Fed implements different policies in response to other economic variables. Baxter (1987) develops a model in which there are two or more policy regimes that the government can follow at any point in time. The probability of changing regimes at a given date is a function of observed economic variables. Therefore the probability of being in a particular regime at a specific future date varies over time in response to changes in the exogenous economic variables. Specifically, there are "trigger levels" of specific economic variables that cause the policymaker to switch from one regime to another. Since current decisions (in the context of the 1979–1982 period, current bond yields) are functions of expected future policies, time–variation in the probabilities of expected future policies induces time–variation in the response of current variables to specific exogenous variables. Exploring this alternative explanation for time–variation in the response of bond yields to money announcements a promising direction for future research into the "money announcements puzzle".

Footnotes

[1]A brief review of the literature is contained below; see Cornell (1983a,b) and the references contained therein for more detail.

[2]Cornell (1983a), p. 22.

[3]Bayesian learning models in a macroeconomic context have been developed by Taylor (1975) and Baxter (1985). Related early work was done by Flood and Garber (1980).

[4]Some authors (Friedman (1984) and McCallum (1984), for example) have suggested that the effective time period was much shorter.

[5]Mascaro and Meltzer (1983), p. 506.

[6]Huizinga and Mishkin (1986), page 232.

[7]The "excess return" on an n-period bond is the holding period return for the bond minus the rate of return on a one-period bond.

[8]Defining a change in a policy regime in a way that is consistent with rational expectations is tricky business, as was pointed out by Cooley, LeRoy, and Raymon (1984). We shall assume that the parameters of government policy functions are themselves random variables which, ex post, change very infrequently. A new policy regime, then, is a change to a new set of policy parameters. Since the probability of a transition from one regime to another is assumed to be small, we ignore the possibility of future transitions in discussing expectations formation by private agents.

[9]Since we are focusing on the determination of expectations of future inflation and its effect on current money demand, we suppress the real interest rate component of money demand and the usual error term in the money demand function.

[10]Baxter (1985) explores this implication of learning models within the context of two Latin American monetary reforms of the late 1970's.

[11]Huizinga and Mishkin (1986) document changes in the time series properties of real rates over roughly the same period.

[12]Roll (1970) devotes most of Chapter 5 to describing his methodology for collecting the data and checking the data set for errors.

[13]In cases where an error in the data seemed likely, the data point was checked against the New York Fed's quote sheet for that day. Perhaps not surprisingly, several errors were found in the data as reported by the Wall Street Journal.

[14]Several authors have, in fact, argued exactly this point. See, for example, Poole (1982), and Cook (1983).

[15]The outlier was found by plotting the leverage measure of the observations. The leverage measure is a diagnostic check contained in the DFIT software package by Pesaran and Pesaran.

[16]Small amounts of low-order serial correlation were found for some forward rates in some time periods. For this reason two lags of the forward rates are included in equation (22).

[17]Unexpected money could also affect real rates and thus affect forward rate revisions. This effect is not explicitly dealt with here, although the story the paper tells is consistent with this view.

[18]Because $(\hat{\theta}_t - \hat{\theta}_{t-1})$ goes to zero asymptotically, the asymptotic standard error of the estimate γ is infinity. In order to perform tests of the hypothesis that $\gamma = 1$ in the regression above, one would need to derive the small sample properties of the estimate via Monte Carlo techniques. Albert Marcet pointed this out to me.

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Table 1

Summary Statistics for One-Week Bill
(continuously compounded annual rate (%))

	Period:	Mean	STD DEV	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	sd(ρ)
	1/3/78–12/20/83	10.25	3.09	.937	.885	.863	.847	.810	.056
	Subperiod:								
I.	1/3/78–10/2/79	8.24	1.50	.918	.878	.862	.835	.787	.103
II.	10/16/79–9/28/82	12.25	3.11	.883	.777	.731	.706	.637	.080
III.	10/5/82–12/20/83	8.28	.56	.576	.357	.339	.377	.223	.125

Table 2
Annualized Forward Rate Revisions

	Means			Standard Deviations		
	Period			Period		
	I	II	III	I	II	III
F_2	0.2056	0.0954	-0.1220	0.4102	1.2216	0.5632
F_3	0.1822	0.3864	0.1800	0.4707	1.7009	0.5729
F_4	-0.0563	-0.2477	-0.0105	0.4396	1.7043	0.6478
F_5	-0.1571	-1.0844	-0.4571	0.4793	1.7745	0.4928
F_6	0.0710	-0.0299	0.1149	0.3893	1.5666	0.4512
F_7	0.0206	0.1610	0.0491	0.4334	1.3662	0.3661
F_8	0.0167	0.0479	-0.0250	0.4715	1.2526	0.4472
F_9	-0.1346	-0.5984	-0.2880	0.4750	1.3695	0.4665
F_{10}	0.1088	-0.0546	0.0309	0.6227	1.3756	0.4682
F_{11}	-0.0117	0.2084	0.0415	0.5968	1.2050	0.4668
F_{12}	0.1433	0.0720	-0.0462	0.7287	1.3850	0.5829
F_{13}	-0.3875	-0.2632	-0.1182	0.8824	2.4903	0.8398
F_{14}	0.5397	0.6903	0.3134	1.2521	2.6784	0.7234
F_{15}	-0.2981	-0.3978	-0.2836	0.9355	1.7074	0.6365
F_{16}	0.1117	-0.2894	-0.0186	0.6320	1.8761	0.6517
F_{17}	-0.0318	0.0752	-0.0550	0.5714	1.3994	0.6663
F_{18}	0.0561	–0.2471	–0.0903	0.5905	1.8536	0.5954
F_{19}	0.4890	-0.5744	-0.4030	0.8302	2.0729	0.6729
F_{20}	0.0346	-0.0402	-0.0246	0.2184	0.6867	0.2605
F_{21}	-0.3679	-0.2401	-0.4269	0.7220	2.2738	0.6816
F_{22}	-0.1267	-0.1474	-0.1141	0.5627	2.4960	0.6099
F_{23}	-0.0179	-0.0708	-0.0070	0.6016	1.8729	0.6753
F_{24}	0.0781	0.0319	0.1311	0.8315	1.4713	0.7058
F_{25}	-0.1144	0.0250	-0.1264	0.7276	1.4144	0.8943

Period I: 1/3/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Table 3
Autocorrelations of Forward Rate Revisions

	Period I					Period II					Period III				
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5
F_2	-.027	-.154	.080	.271	-.042	.083	.104	-.014	.019	-.050	-.181	-.033	-.079	.012	-.070
F_3	.142	-.135	.020	.027	-.195	.271	.005	-.133	.007	.036	.414	.008	.047	.059	-.109
F_4	.053	-.150	.164	.039	-.045	.161	.188	-.039	.002	.072	.121	-.078	-.242	.008	.066
F_5	.005	-.303	.065	.178	-.171	.102	.086	-.010	-.060	.000	.198	.014	-.243	.013	-.007
F_6	.140	-.301	-.051	.053	.112	.059	-.007	-.007	.066	.012	-.158	.130	-.063	-.019	.017
F_7	.089	-.056	-.011	.003	-.051	.183	.035	-.047	-.026	-.091	-.196	.055	.229	-.078	.007
F_8	.077	-.166	-.125	.059	-.023	.177	.022	.147	-.041	.083	.234	.043	.032	-.272	-.124
F_9	.146	.023	.053	.080	-.007	.175	-.021	.045	-.094	-.087	-.031	-.008	.074	.030	.074
F_{10}	.172	-.177	-.129	-.072	-.131	.132	-.035	-.079	.189	.077	-.232	-.022	-.127	.014	.055
F_{11}	.188	.109	.019	.026	.014	.091	.126	-.068	.087	.019	-.003	.045	.018	.077	-.125
F_{12}	-.057	-.240	-.037	.020	-.097	.106	.020	-.043	-.192	-.070	-.214	-.188	.227	-.144	.002
F_{13}	.416	.283	.182	.081	.038	.236	.032	.129	-.031	-.001	.008	-.217	.069	-.104	-.065
F_{14}	.343	.298	.323	.201	.140	.465	.142	-.014	-.003	.013	.196	.008	.100	.041	-.116
F_{15}	.196	.143	.206	-.092	.016	.238	-.003	.074	-.023	-.033	.116	-.200	.046	.201	-.144
F_{16}	.187	.001	.073	.134	.103	.285	.112	.198	.156	.138	-.040	-.167	.102	-.172	.192
F_{17}	.204	-.153	-.165	-.084	.013	.107	.078	.105	.087	.047	.003	-.184	.028	-.137	-.031
F_{18}	.103	-.051	-.110	.197	-.045	.173	.178	-.035	-.055	.023	.193	.200	.131	.095	-.187
F_{19}	.041	.175	.054	.245	.029	.033	-.009	-.123	.058	.045	.103	.192	-.014	.094	.155
F_{20}	.052	-.168	.059	.121	-.026	.209	.182	-.028	.105	.074	-.073	-.133	.042	-.036	-.052
F_{21}	.259	.233	.160	.034	-.024	.252	.337	.194	.105	.127	.103	.074	-.258	-.007	.045
F_{22}	-.104	.110	-.118	-.035	-.184	.183	.154	.013	-.082	-.017	.148	.098	-.102	-.188	.100
F_{23}	.166	.044	.069	.134	-.080	.046	.204	-.015	.057	.125	.083	-.065	.155	.118	.213
F_{24}	.269	-.063	.068	.231	-.047	-.167	.096	-.148	.052	.009	.111	-.178	-.082	.042	-.105
F_{25}	.071	-.149	.013	-.014	.110	.077	.139	.131	-.054	.119	.070	-.198	-.087	-.173	-.038

Standard Error = .104 (Period I); Standard Error = .080 (Period II); Standard Error = .125 (Period III)

Period I: 1/31/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Table 4

Means and Standard Deviations of Monetary Variables

	Means			Standard Deviations		
	Period			Period		
	I	II	III	I	II	III
M1	357.095	419.643	499.489	11.506	25.197	18.259
DLM1	0.130	0.128	0.190	0.578	0.643	0.571
AC	0.297	0.435	0.992	2.089	2.682	2.692
EC	0.740	0.212	0.859	1.241	1.352	1.725
UM	-0.125	0.053	0.031	0.441	0.524	0.405

Period I: 1/10/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Variable Definitions:

M1: **The M1 measure of the money stock (M1B beginning in February 1980)**

DLM1: **Weekly growth rate in M1 (percent)**

AC: **Announced change in the money supply**

EC: **Expected change in the money supply (from survey data)**

UM: **Unexpected change in the money supply (percent)** $UM_t = \left[\frac{AC_t - EC_t}{M1F_{t-1}}\right] \times 100.$

Table 5
Auto-Correlations of Monetary Variables

	Period I					Period II					Period III				
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5
M1	.953	.907	.866	.826	.783	.977	.958	.938	.920	.899	.936	.884	.841	.798	.753
DLM1	−.192	−.222	−.015	.083	.170	−.222	−.089	−.112	.135	.031	−.208	−.007	−.170	.173	−.036
AC	−.253	−.198	−.015	.085	.158	−.286	−.030	−.135	.129	.066	−.294	.137	−.199	.168	−.107
EC	−.097	−.226	−.015	.049	.277	−.059	−.117	−.050	.197	.112	−.072	−.210	−.235	.237	−.012
UM	.005	−.086	.132	.184	.100	−.070	.093	−.016	.075	.073	−.167	.317	−.134	.144	−.032

Period I: 1/10/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Variable Definitions:

M1: The M1 measure of the money stock (M1B beginning in February 1980)

DLM1: Weekly growth rate in M1 (percent)

AC: Announced change in the money supply

EC: Expected change in the money supply (from survey data)

UM: Unexpected change in the money supply (percent) $UM_t = \left[\frac{AC_t - EC_t}{M1F_{t-1}}\right] \times 100.$

Table 6

Testing Unbiasedness of Survey Expectations

(Standard Errors in Parentheses)

$$AC_t = a_0 + a_1 EC_t + \epsilon_t$$

Period I		Period II		Period III	
a_0	a_1	a_0	a_1	a_0	a_1
−0.531 (0.190)	1.117 (0.133)	0.189 (0.177)	1.161 (0.130)	0.161 (0.281)	1.011 (0.148)
R^2: .440		R^2: .343		R^2: .427	

Period I: 1/3/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Table 7

Testing Rationality of Survey Expectations

(Standard Errors in Parentheses)

$$UM_t = a_0 + a_1 UM_{t-1} + \epsilon_t$$

Period I		Period II		Period III	
a_0	a_1	a_0	a_1	a_0	a_1
-0.131 (0.484)	0.005 (0.106)	0.057 (0.042)	-0.070 (0.081)	0.046 (0.050)	-0.186 (0.124)
R^2: .000		R^2: .005		R^2: .034	

Period I: 1/3/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Table 8

$$\Delta R_{n,t} = a_0 + a_1 UM_t + a_2 EC_t + \epsilon_t$$

Dependent Variable	Period I Coefficient Estimates						Period II Coefficient Estimates						Period III Coefficient Estimates					
	a_0	(s.e)	a_1	(s.e)	a_2	(s.e)	a_0	(s.e)	a_1	(s.e)	a_2	(s.e)	a_0	(s.e)	a_1	(s.e)	a_2	(s.e)
ΔR_1	0.064	(0.047)	−0.090	(0.086)	−0.038	(0.032)	−0.018	(0.114)	0.681	(0.217)	−0.162	(0.084)	0.097	(0.066)	0.085	(0.146)	−0.071	(0.034)
ΔR_2	0.082	(0.047)	−0.068	(0.086)	−0.058	(0.032)	−0.013	(0.096)	0.463	(0.182)	−0.139	(0.071)	0.000	(0.054)	0.254	(0.119)	0.044	(0.028)
ΔR_3	0.091	(0.040)	0.019	(0.074)	−0.055	(0.027)	−0.022	(0.079)	0.530	(0.149)	−0.177	(0.058)	0.016	(0.040)	0.205	(0.087)	0.011	(0.020)
ΔR_4	0.094	(0.037)	0.038	(0.069)	−0.052	(0.025)	−0.050	(0.075)	0.697	(0.142)	−0.042	(0.055)	0.011	(0.042)	0.348	(0.094)	0.016	(0.022)
ΔR_5	0.087	(0.036)	0.019	(0.066)	−0.048	(0.025)	−0.029	(0.068)	0.591	(0.128)	−0.101	(0.050)	0.016	(0.031)	0.230	(0.069)	0.012	(0.016)
ΔR_6	0.084	(0.035)	0.025	(0.065)	−0.042	(0.024)	−0.027	(0.063)	0.588	(0.119)	−0.113	(0.046)	0.009	(0.030)	0.295	(0.065)	0.017	(0.015)
ΔR_7	0.087	(0.033)	0.042	(0.061)	−0.044	(0.023)	−0.026	(0.059)	0.585	(0.112)	−0.118	(0.044)	0.019	(0.030)	0.247	(0.066)	0.010	(0.016)
ΔR_8	0.087	(0.032)	0.043	(0.054)	−0.044	(0.022)	−0.025	(0.056)	0.611	(0.107)	−0.128	(0.042)	0.013	(0.029)	0.298	(0.064)	0.013	(0.015)
ΔR_9	0.094	(0.031)	0.060	(0.057)	−0.052	(0.021)	−0.022	(0.054)	0.638	(0.102)	−0.142	(0.040)	0.013	(0.029)	0.248	(0.064)	0.012	(0.015)
ΔR_{10}	0.088	(0.030)	0.047	(0.055)	−0.047	(0.020)	−0.022	(0.054)	0.627	(0.102)	−0.134	(0.040)	0.012	(0.029)	0.262	(0.063)	0.009	(0.015)
ΔR_{11}	0.085	(0.029)	0.056	(0.053)	−0.044	(0.020)	−0.024	(0.053)	0.636	(0.101)	−0.125	(0.039)	0.014	(0.028)	0.255	(0.062)	0.006	(0.014)
ΔR_{12}	0.090	(0.029)	0.075	(0.054)	−0.045	(0.020)	−0.026	(0.053)	0.657	(0.101)	−0.118	(0.039)	0.005	(0.030)	0.264	(0.067)	0.015	(0.016)
ΔR_{13}	0.091	(0.030)	0.072	(0.056)	−0.046	(0.021)	−0.028	(0.053)	0.703	(0.101)	−0.121	(0.039)	−0.002	(0.032)	0.265	(0.070)	0.019	(0.016)
ΔR_{14}	0.076	(0.027)	0.056	(0.050)	−0.031	(0.019)	−0.025	(0.052)	0.635	(0.098)	−0.114	(0.038)	−0.000	(0.031)	0.266	(0.070)	0.019	(0.016)
ΔR_{15}	0.072	(0.024)	0.062	(0.045)	−0.026	(0.017)	−0.026	(0.051)	0.639	(0.097)	−0.105	(0.038)	−0.008	(0.031)	0.268	(0.069)	0.026	(0.016)
ΔR_{16}	0.076	(0.025)	0.047	(0.045)	−0.034	(0.017)	−0.023	(0.048)	0.666	(0.090)	−0.113	(0.055)	−0.018	(0.032)	0.261	(0.071)	0.031	(0.017)
ΔR_{17}	0.073	(0.024)	0.045	(0.045)	−0.030	(0.016)	−0.025	(0.048)	0.673	(0.092)	−0.103	(0.036)	−0.018	(0.032)	0.285	(0.071)	0.030	(0.017)
ΔR_{18}	0.071	(0.024)	0.052	(0.044)	−0.027	(0.016)	−0.023	(0.050)	0.662	(0.095)	−0.106	(0.037)	−0.017	(0.033)	0.265	(0.072)	0.025	(0.017)
ΔR_{19}	0.071	(0.023)	0.063	(0.042)	−0.025	(0.016)	−0.022	(0.049)	0.667	(0.093)	−0.105	(0.036)	−0.024	(0.032)	0.253	(0.072)	0.030	(0.017)
ΔR_{20}	0.070	(0.022)	0.043	(0.041)	−0.028	(0.015)	−0.023	(0.048)	0.650	(0.092)	−0.092	(0.036)	−0.020	(0.034)	0.243	(0.075)	0.024	(0.017)
ΔR_{21}	0.068	(0.022)	0.052	(0.040)	−0.024	(0.015)	−0.022	(0.046)	0.638	(0.087)	−0.091	(0.034)	−0.021	(0.033)	0.255	(0.073)	0.022	(0.017)
ΔR_{22}	0.069	(0.021)	0.068	(0.039)	−0.021	(0.014)	−0.020	(0.046)	0.624	(0.087)	−0.098	(0.034)	−0.024	(0.033)	0.250	(0.073)	0.024	(0.017)
ΔR_{23}	0.065	(0.020)	0.055	(0.037)	−0.019	(0.014)	−0.020	(0.046)	0.616	(0.088)	−0.096	(0.034)	−0.024	(0.034)	0.257	(0.076)	0.022	(0.018)
ΔR_{24}	0.064	(0.020)	0.049	(0.038)	−0.019	(0.014)	−0.020	(0.046)	0.598	(0.086)	−0.087	(0.034)	−0.025	(0.034)	0.272	(0.075)	0.023	(0.018)
ΔR_{25}	0.068	(0.021)	0.054	(0.038)	−0.023	(0.014)	−0.020	(0.045)	0.598	(0.086)	−0.088	(0.033)	−0.024	(0.036)	0.272	(0.079)	0.023	(0.019)

Period I: 2/07/78–10/2/79
Period II: 10/9/79–9/28/82
Period III: 10/5/82–12/20/83

Table 9

$$F_{n,t} = A_0 + a_1 F_{n,t-1} + a_2 F_{n,t-2} + \phi_1 UM_t + \phi_2 EC_t + \epsilon_t$$

	Period I				Period II				Period III			
	$\hat{\phi}_1$	(s.e.)	$\hat{\phi}_2$	(s.e.)	$\hat{\phi}_1$	(s.e.)	$\hat{\phi}_2$	(s.e.)	$\hat{\phi}_1$	(s.e.)	$\hat{\phi}_2$	(s.e.)
F_2	-.032	(.091)	-.153	(.117)	.638	(.185)	-.185	(.308)	.301	(.160)	.525	(.188)
F_3	.129	(.104)	-.057	(.136)	.283	(.260)	-.230	(.428)	.108	(.178)	.119	(.208)
F_4	.058	(.109)	-.197	(.140)	.847	(.252)	-.031	(.424)	.793	(.196)	-.262	(.217)
F_5	.010	(.109)	-.150	(.140)	.574	(.275)	-.274	(.458)	.305	(.147)	.403	(.161)
F_6	.134	(.090)	-.060	(.115)	.661	(.235)	-1.085	(.393)	.206	(.138)	-.082	(.160)
F_7	.133	(.101)	-.185	(.131)	.416	(.207)	-.597	(.345)	.219	(.118)	-.084	(.135)
F_8	.083	(.119)	-.071	(.152)	.572	(.186)	-.620	(.312)	.395	(.133)	.147	(.154)
F_9	.149	(.115)	-.297	(.152)	.796	(.202)	-.583	(.337)	.261	(.148)	-.013	(.166)
F_{10}	-.110	(.145)	-.202	(.194)	.730	(.204)	-.813	(.344)	-.090	(.154)	-.117	(.175)
F_{11}	.227	(.142)	.070	(.187)	.537	(.183)	-.075	(.312)	.158	(.149)	.114	(.167)
F_{12}	.283	(.181)	-.091	(.241)	.657	(.210)	-.056	(.356)	.277	(.170)	.263	(.194)
F_{13}	.079	(.200)	-.096	(.258)	1.120	(.368)	.334	(.621)	.197	(.245)	.256	(.312)
F_{14}	-.102	(.249)	.087	(.325)	.730	(.358)	-1.257	(.602)	.388	(.267)	.179	(.327)
F_{15}	.038	(.226)	-.049	(.296)	.160	(.259)	.355	(.433)	.162	(.184)	.703	(.210)
F_{16}	-.140	(.145)	.158	(.192)	.925	(.271)	-.123	(.456)	.290	(.214)	.473	(.246)
F_{17}	.064	(.136)	-.197	(.178)	.683	(.211)	-.523	(.350)	.656	(.195)	.032	(.240)
F_{18}	.056	(.207)	-.097	(.269)	.912	(.273)	-.290	(.457)	.197	(.188)	.336	(.208)
F_{19}	.049	(.206)	-.091	(.268)	.573	(.323)	-.325	(.537)	.145	(.210)	-.267	(.240)
F_{20}	.069	(.043)	-.082	(.055)	.644	(.090)	-.399	(.154)	.261	(.075)	.159	(.088)
F_{21}	.096	(.164)	.129	(.214)	.572	(.331)	-.360	(.546)	.380	(.206)	.278	(.228)
F_{22}	.312	(.133)	.112	(.174)	-.135	(.390)	-.390	(.638)	.384	(.191)	-.088	(.236)
F_{23}	.095	(.148)	-.287	(.192)	.672	(.284)	-.773	(.477)	.190	(.212)	.210	(.250)
F_{24}	.155	(.190)	.440	(.249)	-.048	(.228)	.108	(.383)	.551	(.217)	-.058	(.244)
F_{25}	-.139	(.178)	-.307	(.235)	.764	(.213)	.169	(.366)	.541	(.275)	.234	(.339)

Period I: 1/24/78–9/25/79
Period II: 10/2/79–9/2/82
Period III: 9/28/82–12/20/83

Table 10

$$F_{n,t} = \alpha_0 + \alpha_1 F_{n,t-1} + \alpha_2 F_{n,t-2} + \gamma(\hat{\theta}_t - \hat{\theta}_{t-1}) + \psi_1 UM_t + \psi_2 EC_t + \epsilon_t$$

Period II: 11/5/79–9/21/82

	$\hat{\gamma}$	$\hat{\psi}_1$	(s.e.)	$\hat{\psi}_2$	(s.e.)
F_2	−4.287	.720	(.226)	−.148	(.319)
F_3	−1.109	.299	(.316)	−.232	(.445)
F_4	−0.299	.854	(.310)	−.031	(.443)
F_5	−3.803	.614	(.336)	−.240	(.477)
F_6	−2.701	.701	(.289)	−1.064	(.410)
F_7	−2.057	.449	(.251)	−.593	(.358)
F_8	−9.437	.734	(.225)	−.521	(.322)
F_9	−1.202	.793	(.245)	−.590	(.350)
F_{10}	2.646	.681	(.246)	−.861	(.355)
F_{11}	2.510	.516	(.222)	−.097	(.322)
F_{12}	3.492	.583	(.256)	−.103	(.369)
F_{13}	19.438	.779	(.444)	.086	(.641)
F_{14}	15.657	.377	(.421)	−1.458	(.603)
F_{15}	−13.144	.493	(.303)	.496	(.432)
F_{16}	−7.288	1.009	(.327)	−.044	(.467)
F_{17}	2.074	.600	(.256)	−.542	(.362)
F_{18}	6.195	.799	(.285)	−.371	(.460)
F_{19}	0.226	.568	(.341)	−.328	(.543)
F_{20}	−.155	.636	(.108)	−.402	(.157)
F_{21}	−10.195	.778	(.407)	−.271	(.569)
F_{22}	4.833	−.275	(.476)	−.438	(.668)
F_{23}	1.119	.680	(.346)	−.789	(.500)
F_{24}	.336	−.072	(.278)	.110	(.397)
F_{25}	16.053	.482	(.255)	−.022	(.373)

The standard errors for $\hat{\gamma}$ are not reported since the small sample properties of $\hat{\gamma}$ are unknown. The asymptotic variance of $\hat{\gamma}$ is not defined.

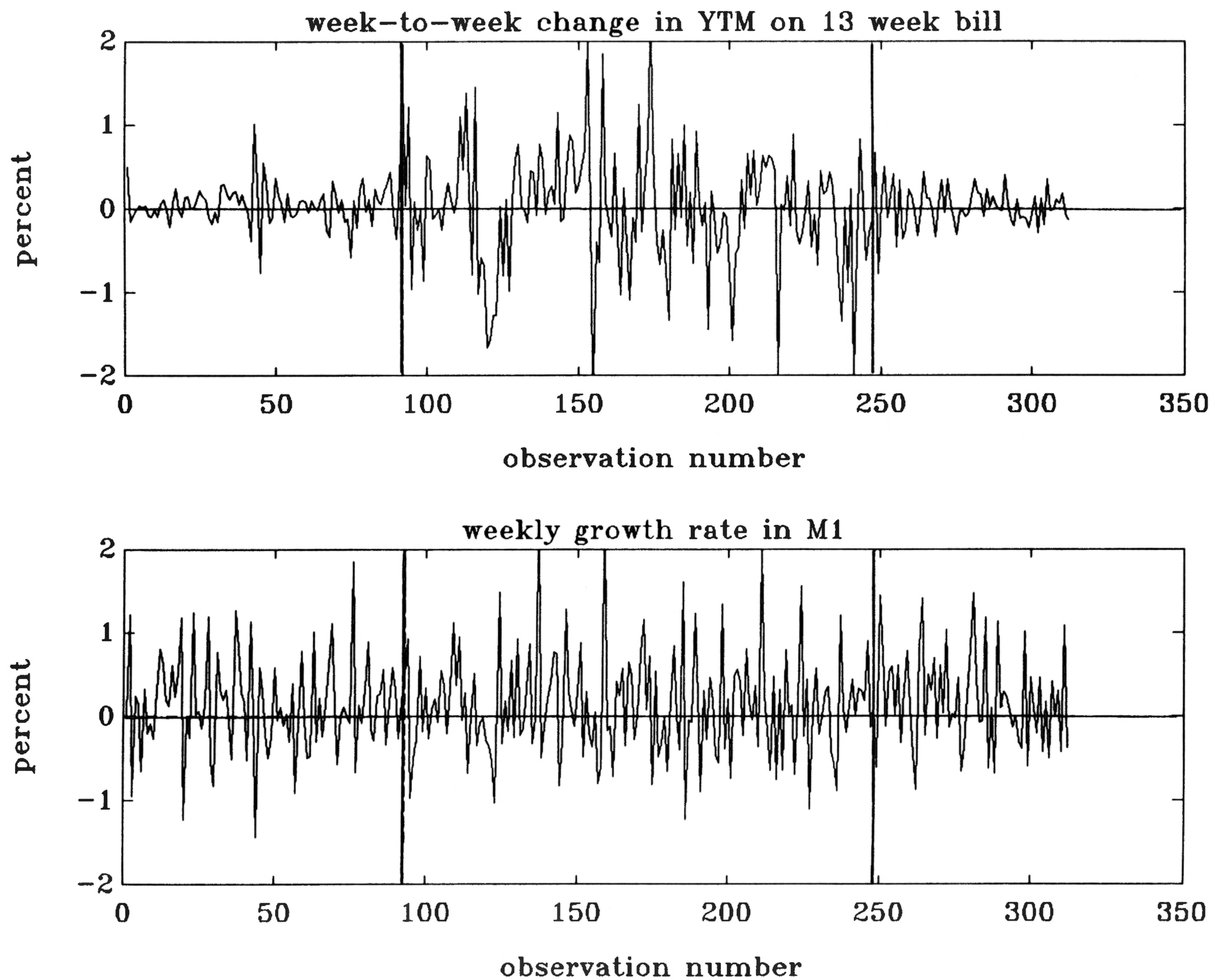

week–to–week change in YTM on 13 week bill
percent
observation number
weekly growth rate in M1
percent
observation number

Figure 1

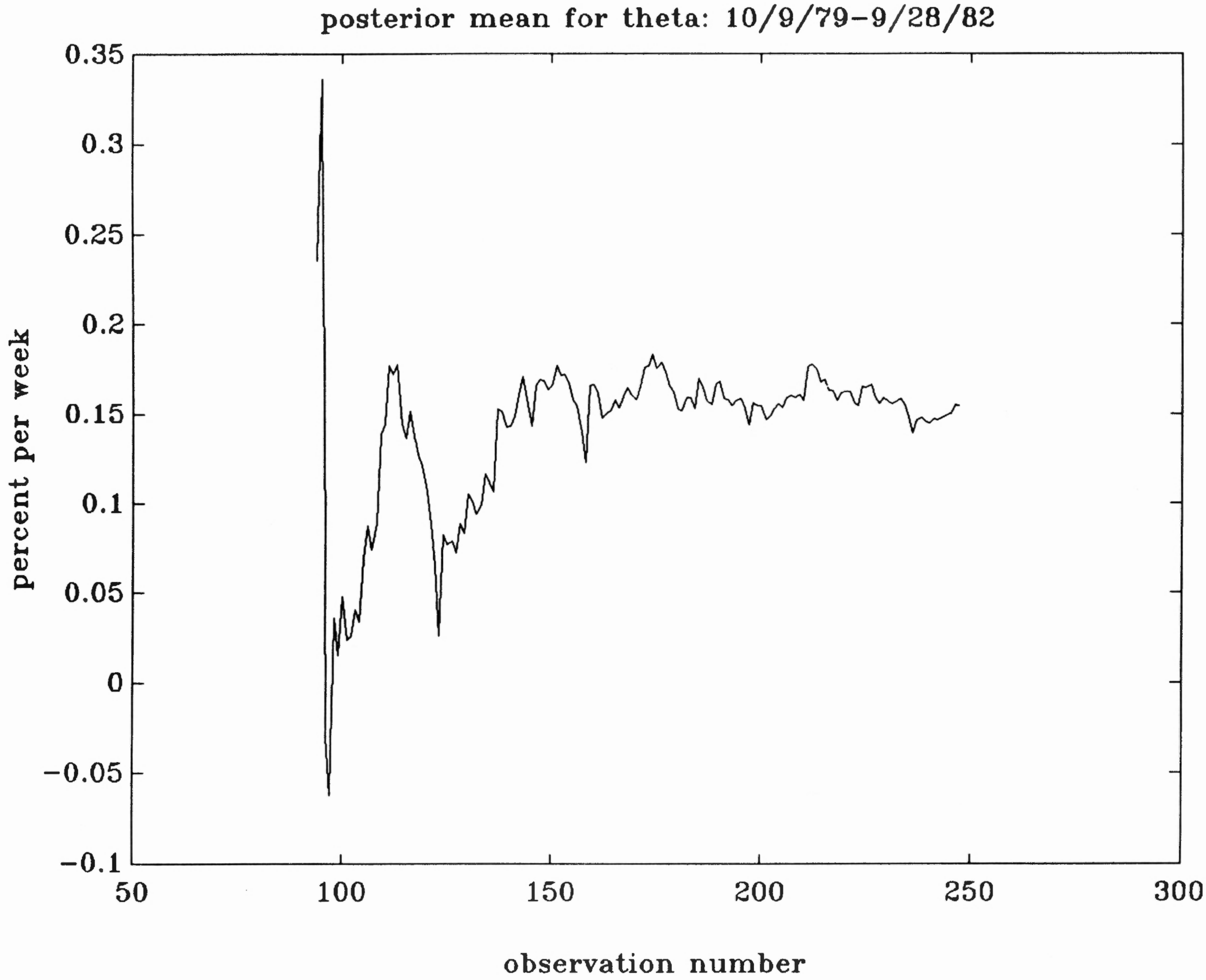
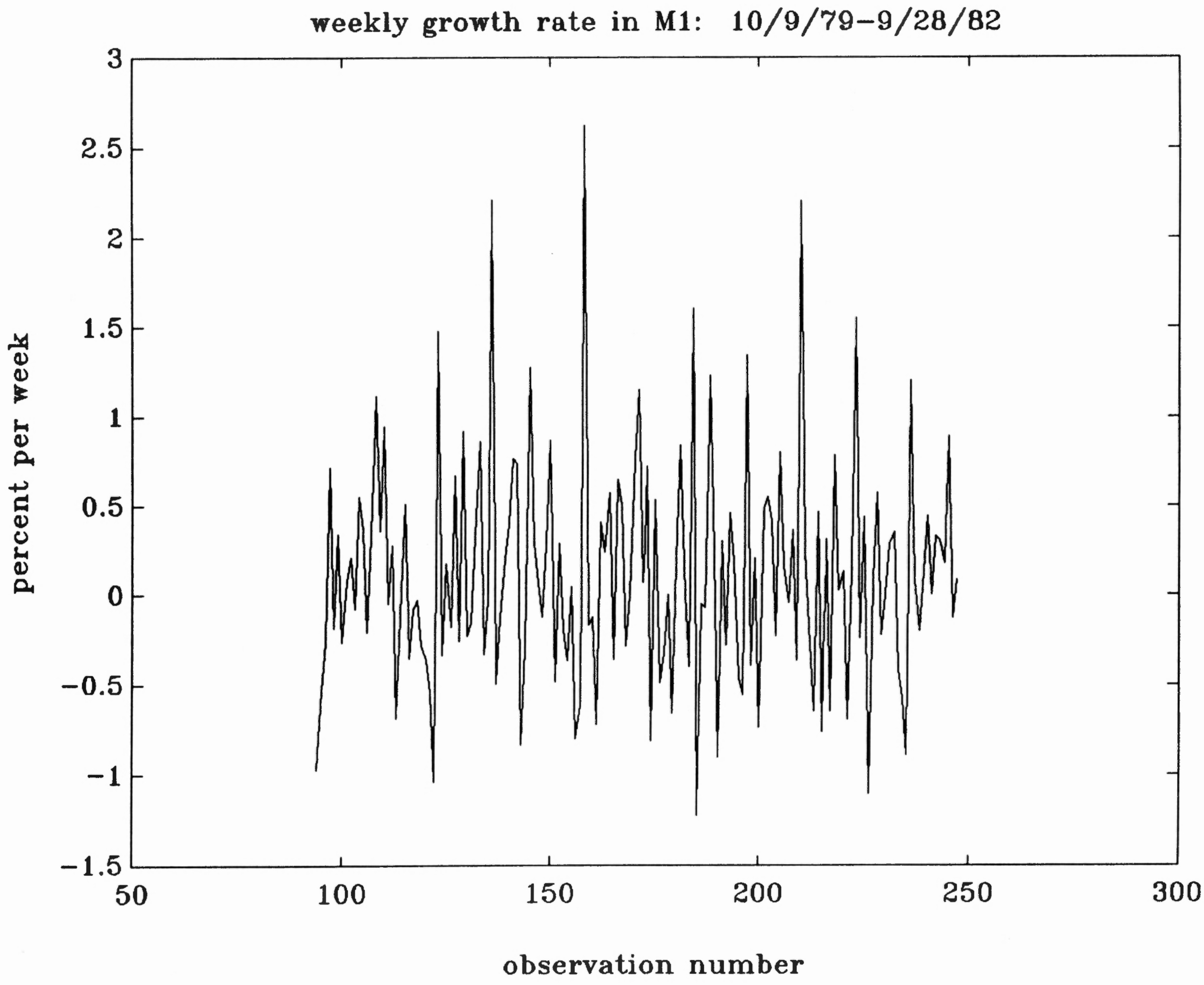
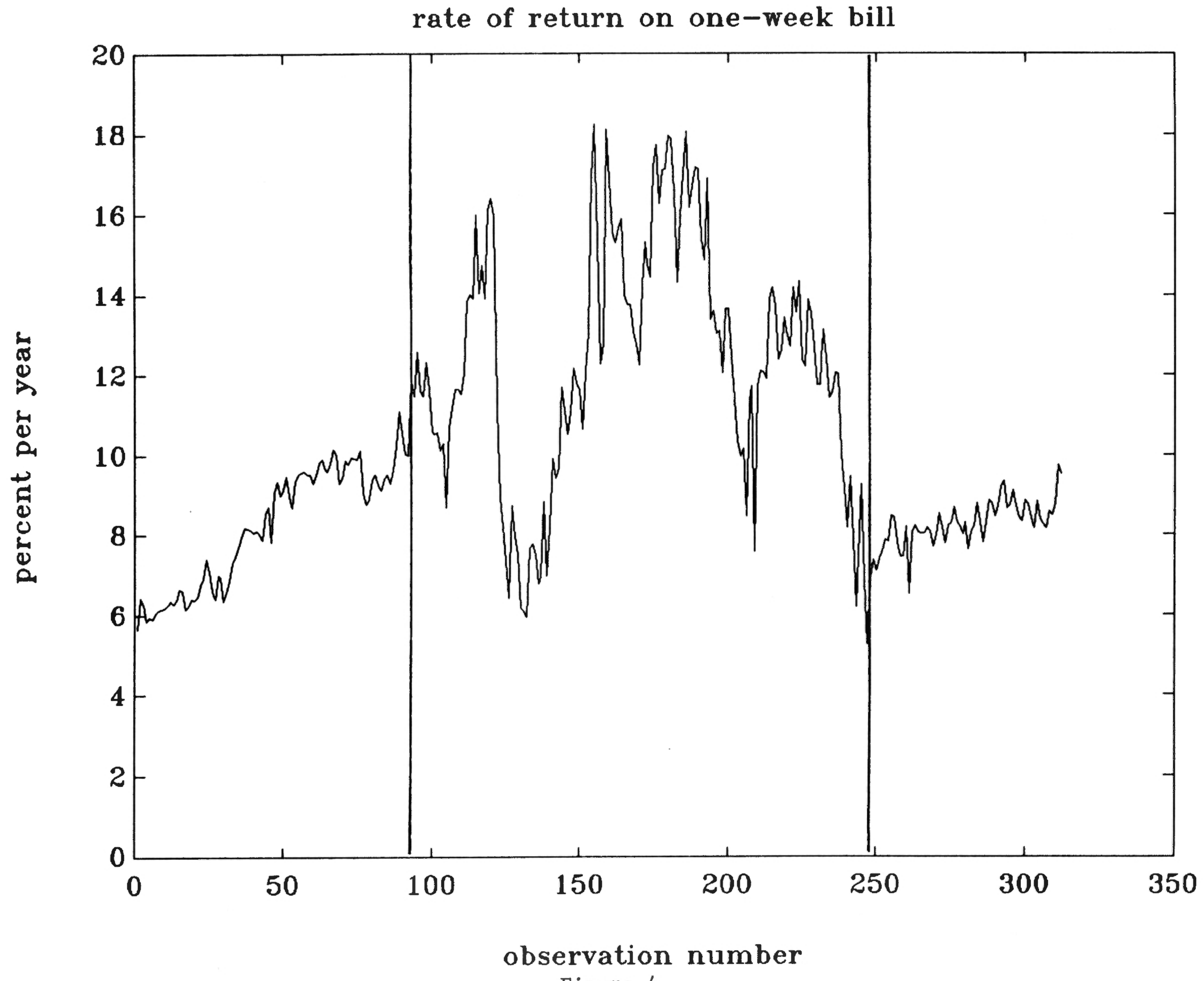
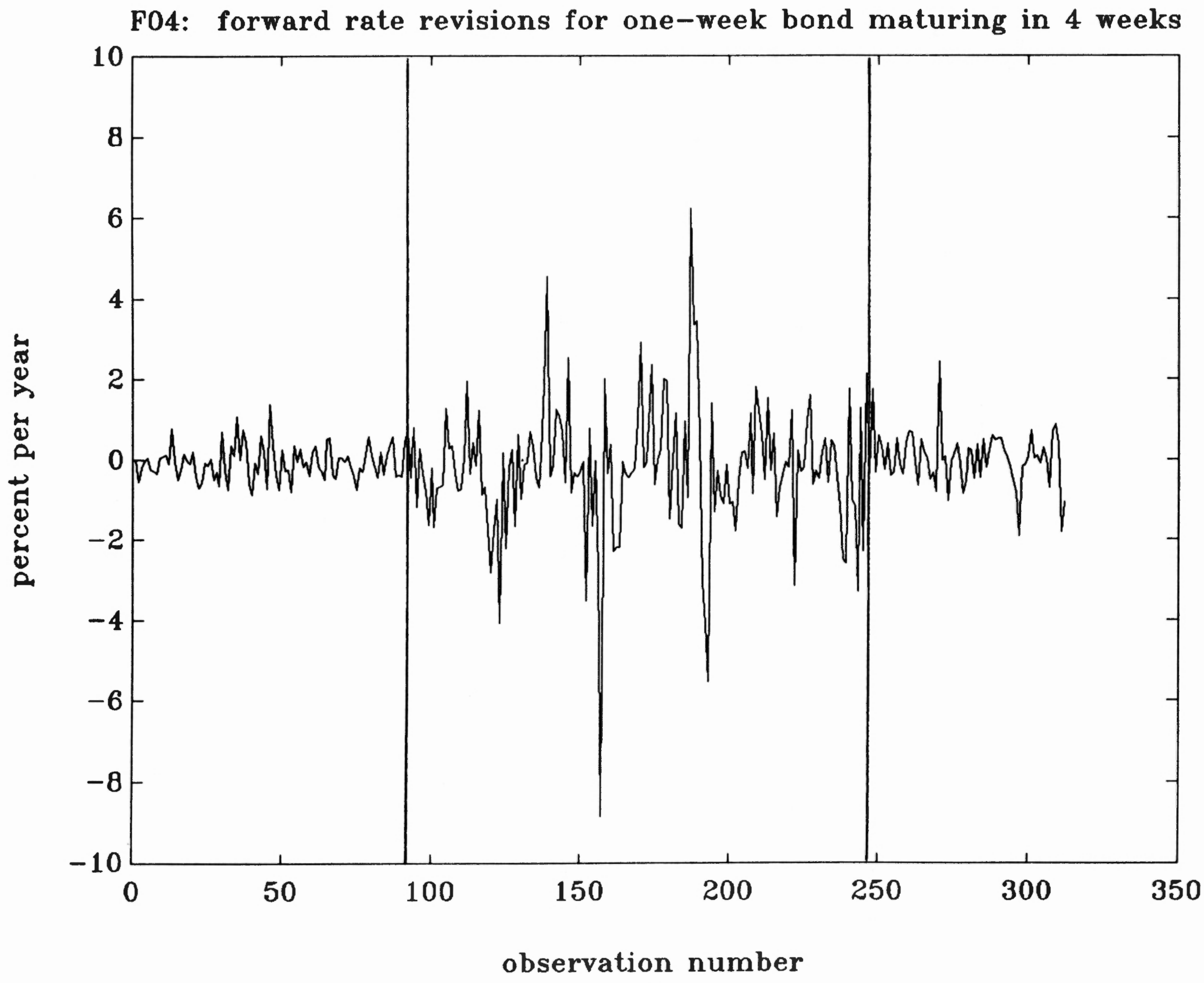

posterior mean for theta: 10/9/79-9/28/82
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
percent per week
50
100
150
200
250
300
observation number

Figure 2


weekly growth rate in M1: 10/9/79-9/28/82
percent per week
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
50
100
150
200
250
300
observation number
Figure 3


rate of return on one-week bill
percent per year
20
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
observation number
Figure 4


F04: forward rate revisions for one-week bond maturing in 4 weeks
percent per year
10
8
6
4
2
0
−2
−4
−6
−8
−10
0
50
100
150
200
250
300
350
observation number
Figure 5

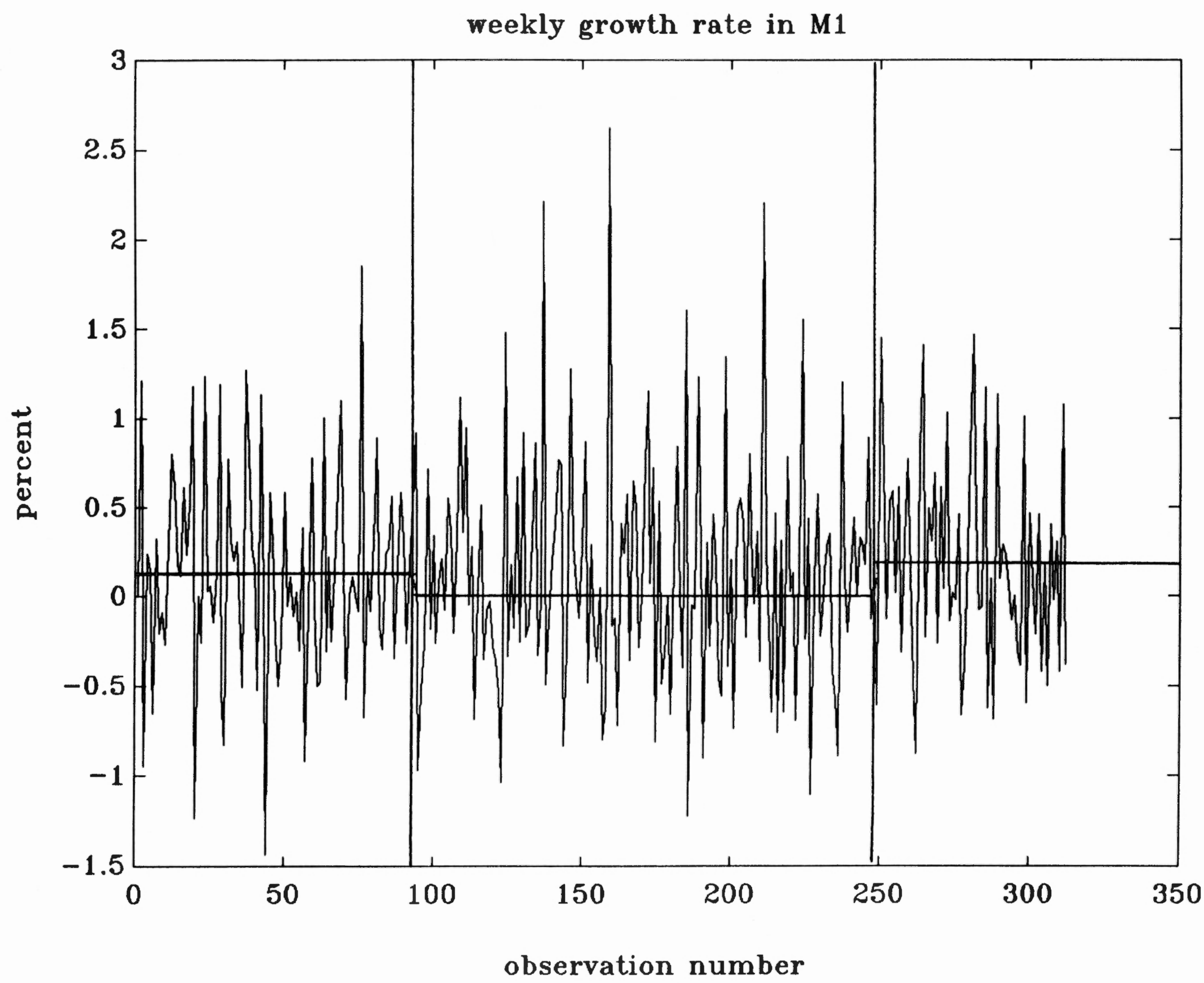

weekly growth rate in M1
percent
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
0
50
100
150
200
250
300
350
observation number

Figure 6

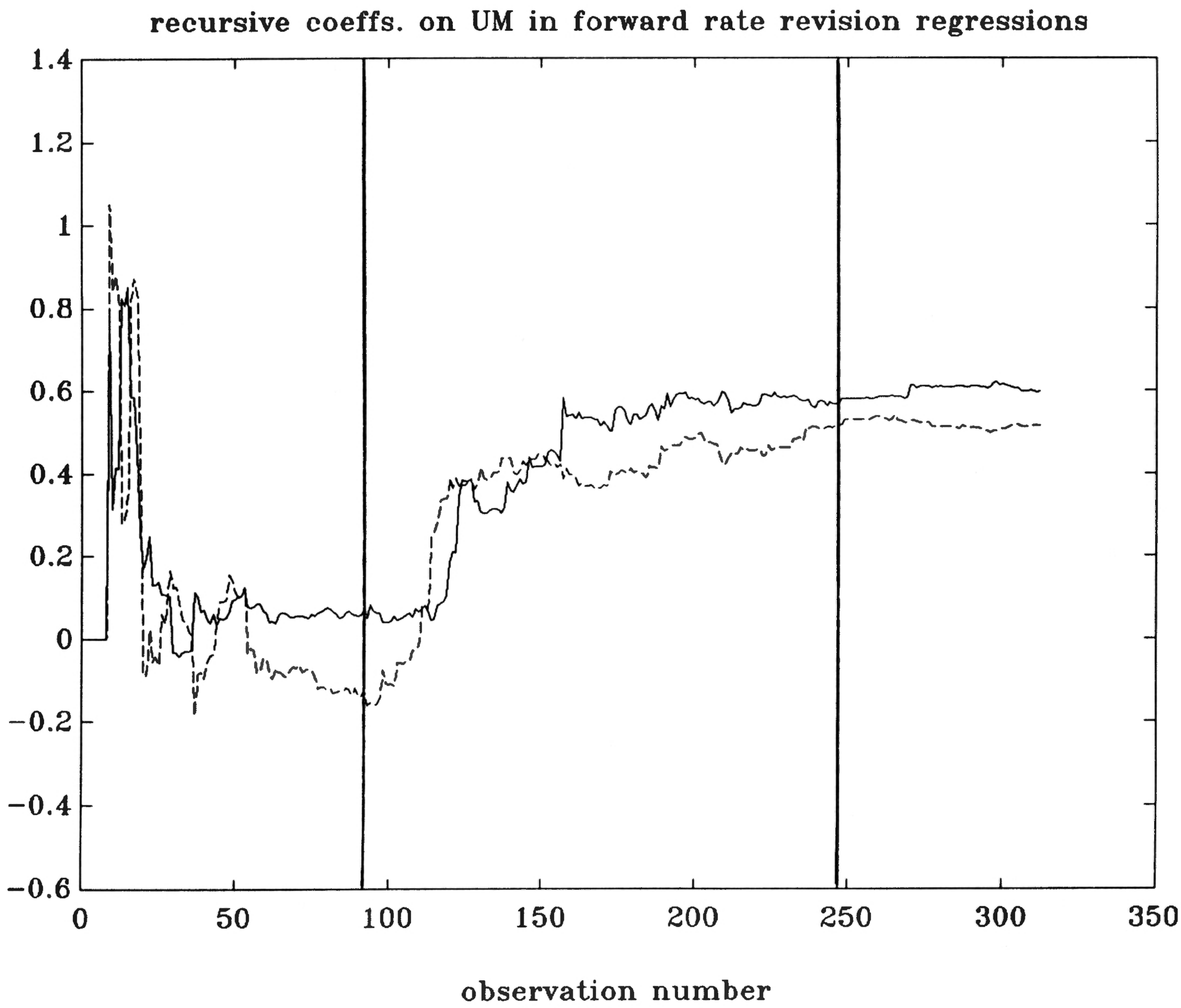

recursive coeffs. on UM in forward rate revision regressions
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
0
50
100
150
200
250
300
350
observation number

Figure 7

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