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The Pavlovian Response to Fed Announcements*

Abstract

In February 4, 1994 the Federal Reserve began the practice of announcing changes in the targeted level for the federal funds rate immediately after such decisions were made. This paper investigates to what extent the policy of "the announcement" affected two key ingredients in the monetary transmission mechanism: the liquidity effect and the term structure of nominally risk-free, Treasury securities. With respect to the liquidity effect, evidence based on a VAR shows that the potency of open market operations dramatically increases during maintenance periods in which an announcement is made. Similarly, term rates react much more in unison during announcement days than at any other time. The practice of circumscribing almost all changes in the federal funds rate target to FOMC dates regiments the formation of market expectations in the overnight rate and the price discovery process of term rates, thus facilitating the Fed's goal of controlling long-term rates.

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> Chairman Greenspan: "Look, the main issue here is that, as far as I am concerned, I would like us to be counted. We are the central bank and we are making a major move," *Transcript of the Federal Open Market Committee Meeting, February 3-4, 1994.*

1. Introduction

The Federal Open Market Committee (FOMC) meeting held on February 3-4, 1994 marked the first change in the federal funds rate target (or target for brevity) since September 4, 1992. During that meeting, a reasonable portion of the discussion centered on the need to make the committee's intentions clear to the public – after all, rates had remained unchanged for over a year and it had been five years since the Federal Reserve last took a tightening stance. The meeting concluded with the most significant procedural change since Chairman Volcker experimented with a nonborrowed reserves target in 1979-1982: the 25 basis point increase in the federal funds rate target would be made public immediately at the meeting's conclusion. Since that meeting in February 3-4, 1994, the Federal Reserve (Fed) has continued the practice of publicly disclosing any changes in the targeted level for the federal funds rate.

In this paper we will argue that this procedural change has added a new operational tool to the Fed's arsenal: the announcement effect. The practice of announcing each change in the target affects the monetary transmission mechanism in two ways: (1) it increases the potency of the liquidity effect during maintenance periods in which there is an announcement; and (2) it regiments the formation of expectations and price discovery process of nominally, risk-free, Treasury securities. Consequently, the Trading Desk of the Federal Reserve Bank of New York ("Desk" hereafter) requires a smaller volume of open market operations to bring the federal funds rate to its new targeted level. The Pavlovian response of the banking system to the announcement causes trading in the federal funds market to accommodate the announced change in advance of any action by the Desk. Therefore, as long as the Desk reaffirms its commitment to the new target level with open market operations in subsequent days, this Pavlovian response unburdens the Desk from having to signal the market with large volumes of open market operations.

The holy grail of monetary policy is to affect long-term rates, and ultimately economic activity, by adequately manipulating expectations. We will show that by announcing when the target is changed term rates of Treasury securities tend to move in unison and in a manner consistent with the rational expectations hypothesis during announcement days. More specifically, we will show that most of the variation in term rates outside announcement days is due to a Fisherian effect. However, a change in the target, particularly when this change reverses the general trend of previous target changes, causes a substantial revision of long-term expectations on the federal funds rate.

Modern central banking is characterized, at a minimum, by public announcements of an interest rate target (such as the federal funds rate in the U.S.), sometimes, by additionally disclosing an inflation target (such as the Bank of Australia, and the Bank of England), and in the extreme, by making the parameters of the policy reaction function publicly available, such as the Reserve Bank of New Zealand. With regard to New Zealand, Guthrie and Wright (2000) investigate a phenomenon that is related to the one under scrutiny in this paper and which they label "open mouth operations."

The equivalent of the federal funds rate in New Zealand is called the cash rate, which is determined by a monetary conditions index and is kept in alignment because the Reserve Bank of New Zealand effectively controls the lending and deposit rates on overnight settlement cash. These two rates act as a ceiling and a floor within which the cash rate is allowed to trade freely (Woodford, 2000 labels this mechanism of control, the "channel system"). Open mouth operations occur whenever the Reserve Bank announces a new target for the official cash rate. This announcement constitutes a departure from the rate suggested by the monetary conditions index and is therefore a complete surprise to the market.

Unlike New Zealand, most changes in the federal funds rate target are widely anticipated (we present formal evidence on this point), and while reserve deposits in the U.S. do not pay interest, the mechanism that gives rise to open mouth operations in Guthrie and Wright (2000) bears some resemblance to the announcement effect we investigate. The formal theoretical characterization of the announcement effect in the U.S. can be found in Taylor (2001). At a daily frequency, Thornton (2000) does not find evidence in support of the announcement effect for the periods 1974-1979; 1984-1989;

and 1989-1997. In contrast, we will emphasize the differences that exist between the 1984/1989-1994 and the 1994-2000 periods by taking the February 3-4, 1994 policy change as our break point.

The remainder of the paper is organized as follows. Section 2 provides a brief institutional background with the salient changes in procedure that have taken place at the Fed. Sections 3 and 4 reconcile conventional VAR estimates of the liquidity effect with the announcement effect and provide new empirical evidence. Section 5 investigates the response of term rates on the days of announcements and shows how expectations are modified accordingly. Section 6 concludes.

2. Institutional Overview

In this paper, we concentrate on the period April 25, 1984 to August 14, 2000 during which the Fed has maintained relatively stable operating procedures. After the 1979-1982 nonborrowed reserves targeting experiment, the Fed gradually moved to a borrowed reserves targeting procedure, and eventually, to a federal funds rate target. According to Meulendyke (1998): "The procedures allowed a much smaller degree of variation in the funds rate than the nonborrowed reserves procedures that had preceded it," although "[…] policy intentions were less transparent than with direct federal funds rate targeting" (p. 53). The informal move from borrowed reserves targeting to a direct funds rate targeting was hastened by the stock market crash in October 19, 1987 – a practice that has been maintained until today.

With the backdrop of the federal funds targeting regime that characterizes the majority of our sample (and in fact, for practical purposes, Hamilton and Jordá, 2000 argue that with a stable demand for reserves, targeting borrowed reserves is virtually equivalent to targeting the funds rate), the institutional break point that we emphasize in the paper is the policy of publicly announcing changes in the funds rate target that was instituted in the February 3-4, 1994 FOMC meeting. However, it is important to highlight at least a couple of additional institutional changes.

In January 1994 the Fed introduced "retail sweep programs." According to Anderson and Raasche (2000), the essence of these programs is computer software that dynamically reclassifies customer deposits between *transactions deposits* (which are subject to reserve requirements) and money market accounts (*non-transaction deposits* which are not subject to reserve requirements). Consequently, in addition to cutting reserve requirements in 1990 and in 1992, required reserves have declined from about $60 billion in 1994 to below $40 billion in 2000 (see Figure 1). Furthermore the relative weight of non-transaction to transaction deposits has increased from a 2:1 ratio in 1994 to a 5:1 ratio in 2000 (see Figure 2). Therefore, Anderson and Raasche (2000) suggest that deposit-sweep activity has reduced the economic burden of statutory reserve requirements to essentially zero.

Banks hold deposits at the Federal Reserve primarily for three reasons: (1) to meet statutory reserve requirements; (2) to clear day to day interbank transactions mediated by the Fed (clearing balances); and (3) to prevent shortfalls in the requirement or to prevent overdrafts on clearing balances (excess reserves). However, the volatile nature of daily interbank transactions (the flow of payments and receipts is around 30 times greater than a bank's overnight reserve balance according to Furfine, 2000) overshadows the uncertainty on reserve requirements and motivates the banks' desire to maintain excess reserves. This desire also reflects the banks' reluctance to use the discount window and borrow reserves, despite the fact that the discount rate is typically well below the federal funds rate. This attitude, motivated by such events as the collapse of the Continental Illinois Bank and Trust Company and other similar failures in the mid-eighties, justifies why borrowed reserves have dwindled to essentially zero from volumes in excess of $7 billion at the height of the savings and loans crisis of the mid-eighties (see Figure 3). These developments will help us characterize the reserves market in the next section.

3. Modeling the Reserves Market and Measuring the Announcement Effect

The standard assumption in most models of the monetary transmission mechanism is that the Fed influences the federal funds rate via open market operations. In fact, "To implement the FOMC's policy instructions, the open market area seeks to manage reserve levels of depository institutions in a way that will encourage the federal funds rate to trade around the level agreed to by the [Federal Open Market] Committee," (Meulendyke, 1998, p. 139). Under this view, innovations on a monetary aggregate directly controlled by the Fed (under suitable identification conditions) are often equated to policy innovations and are used to measure the liquidity effect (i.e., the response of the federal funds rate to these monetary innovations).

However, numerous papers that share this view have not been successful in measuring the liquidity effect (see Pagan and Robertson, 1995 for a survey). Strongin (1995) perhaps offers the most lucid clues that justify this lack of success: there are many instances in which the Fed accommodates demand innovations, which failure to properly identify, can lead one to believe that they are policy driven. Strongin's (1995) measurement of the liquidity effect involves a more careful investigation of the market for reserves, a perspective that has been adopted in numerous other papers (see, Bernanke and Mihov, 1998a, b; Hamilton, 1997; Leeper, Sims and Zha, 1996 to name a few). Consequently, we will use Strongin's (1995) model as our starting point in building a model that makes explicit how one can measure the announcement effect.

3.1 Strongin's Model of the Reserves Market

The stylized model of the reserves market (described for example in Gilbert, 1985; Heller, 1988; and Goodfriend and Whelpey, 1993) describes a downward sloping demand schedule for reserves as a function of the federal funds rate. The supply of reserves is then depicted as a kinked schedule – a perfectly inelastic supply of reserves section corresponding to the level of nonborrowed reserves determined by open market operations; and an upward sloping section corresponding to discount window borrowing.

The slope of the latter section of the supply schedule is then essentially characterized by the spread existing between the discount rate and the federal funds rate. Strongin (1995) then argues that the demand for reserves is completely inelastic in the short-run and therefore, an open market sale that has the effect of shifting the supply schedule to the left will increase the equilibrium level of the federal funds rate and will increase the amount of borrowed reserves by a proportionate amount, leaving total reserves unchanged.

In its innovation form (i.e., the residuals from the reduced form representation of the corresponding VAR), Strongin's (1995) model can be summarized by the following relations:

$$\begin{array}{ccccc} u_{nbr} & = & v_s & + & \phi v_d \\ u_{br} & = & -v_s & + & (1-\phi) v_d \\ \hline u_{tr} & = & & & v_d \end{array} \qquad (1)$$

$$u_{ff} = \lambda v_s + \pi v_d + v_{ff}$$

where the u_i for $i = nbr, br, tr, ff$ refer to the reduced form innovations for nonborrowed reserves, borrowed reserves, total reserves, and the federal funds rate respectively; v_s represents a policy supply shock, v_d represents a reserve demand shock, and v_{ff} represents a funds rate innovation. The parameter ϕ describes how reserve demand accommodations are split between nonborrowed reserves and borrowed reserves.

The model described in (1) indicates that a positive supply innovation in nonborrowed reserves is *exactly* offset by a reduction in borrowed reserves (i.e., demand for reserves is completely inelastic), thus guaranteeing that innovations to total reserves contain the accommodation of demand innovations only. Structural identification of supply shocks can be calculated as the orthogonal component of nonborrowed reserves to total reserve innovations, or more specifically, by choosing a Wold causal ordering that places total reserves ahead of nonborrowed reserves, with the federal funds rate ordered last. Subsequently, the liquidity effect can be easily measured as the impulse response of the federal funds rate to innovations in nonborrowed reserves.

3.2 The Reserves Market without Borrowed Reserves

Our initial points of departure from Strongin's (1995) model are motivated by the discussion in Section 2. In particular, we argue that it is unlikely that the demand for reserves is completely inelastic, even in the very short-run, given the availability of retail-sweep programs. In addition, the observed reluctance of banks to use the discount window suggests that banks prefer to cushion reserve shortfalls, not by going to the discount window, but by depleting excess reserves. Consequently, excess reserves (which are computed as the difference between total reserves and required reserves) will vary according to both supply and demand innovations, or in a notation similar to that in (1),

$$u_{er} = \gamma v_s - \psi v_d \qquad (2)$$

where γ represents the portion of a positive supply innovation absorbed by a countervailing increase in excess reserves, and ψ represents the portion of a demand shock buffered by excess reserves rather than by borrowing reserves from the discount window. With this modification, the model in (1) can be recast as follows

$$\begin{array}{rcrcl} u_{nbr} & = & v_s & + & \phi(1-\psi)\, v_d \\ u_{br} & = & -(1-\gamma)\, v_s & + & (1-\phi)v_d \\ \hline u_{tr} & = & \gamma v_s & + & (1-\psi)v_d \end{array} \qquad (3)$$

so that u_{tr} no longer contains demand innovations exclusively. Expression (3) nests Strongin's original formulation in (1) by setting $\gamma = \psi = 0$, while setting $\gamma = \psi = 1$ corresponds to the extreme case in which banks refuse to make any use of the discount window and use their management of excess reserves instead. From equations (2) and (3) and noting that total reserves are the sum of required reserves and excess reserves, we have,

$$
\begin{array}{rcccc}
u_{tr} & = & \gamma v_s & + & (1-\psi)v_d \\
-u_{er} & = & -\gamma v_s & + & \psi v_d \\
\hline
u_{rr} & = & & & v_d
\end{array}
\tag{4}
$$

so that it is required reserves (instead of total reserves) the component that contains demand innovations exclusively. As a result, the liquidity effect can be computed with a VAR that contains required reserves, nonborrowed reserves and the federal funds rate, instead. Notice that supply innovations can be easily computed as the orthogonal component of nonborrowed reserves to *required reserves* – the impulse responses to policy innovations can be calculated with the Cholesky decomposition and the Wold causal ordering: required reserves ahead of nonborrowed reserves, and in turn, ahead of the federal funds rate.

3.3 Identifying the Announcement Effect and the Liquidity Effect

The model described in equation (4) would typically allow us to measure the liquidity effect as the response of the federal funds rate to innovations in nonborrowed reserves, in a manner similar to what Strongin (1995) suggested. However, how could we measure the announcement effect? A natural approach is to investigate whether or not the federal funds rate responds differently to shocks in nonborrowed reserves during days in which the funds rate target was changed (and after 1994, announced), relative to the remaining days in the sample. If there truly exists an announcement effect, then the potency of the liquidity effect will be much larger during announcement days: the funds rate will move in response to the target change announcement with comparatively fewer open market operations. Accordingly, we propose estimating a two-state VAR model in which the switch between states is regulated by whether or not there was a target change. This two-state model will then allow us to compute the impulse responses of the federal funds rate to nonborrowed reserves in each of these states. Finally, we will compare these responses between VARs estimated over the periods before and after the February 3-4, 1994 break point. The next section presents the specific implementation of this empirical strategy.

4. Empirical Evidence of the Announcement Effect

In order to measure the announcement effect empirically, it is best to use data at the highest frequency available. Reserve accounting is done over a two-week interval called the maintenance period during which banks are dictated to meet their daily average reserve requirement. Hence, the highest frequency at which reserves data are available is with maintenance period regularity. Accordingly, we examine maintenance-period, bi-weekly frequency data (which start on a Thursday and end on settlement Wednesday) for the periods spanning April 25, 1984 to February 4, 1994 (256 observations); and February 4, 1994 to August 14, 2000 (172 observations). For each of these two periods, we estimate a two-state VAR whose switching between states is regulated by whether or not the funds rate target was changed during the current maintenance period or not. The VARs include the three variables specified by the model in (4), normalized by lagged total reserves as suggested by Strongin (1995). This normalization makes the variables stationary while preserving the linear relations that exist among their innovations.

More specifically, let X_t = (*RRX, NBRX, FF*)' denote a vector of variables that includes the ratio of required reserves to lagged total reserves, the ratio of nonborrowed reserves to lagged total reserves, and the federal funds rate, respectively.[1] Let $z_t = 1$ if the target is changed during the t^{th} maintenance period, 0 otherwise. Then, consider the following system,

$$X_t = (1 - z_t)\Pi_1(L)X_{t-1} + z_t\Pi_2(L)X_{t-1} + \varepsilon_t \tag{5}$$

where $\Pi_i(L)$ denotes a finite lag polynomial for $i = 1,2$. From this system, we can compute the impulse responses of the funds rate to innovations in nonborrowed reserves to calculate the liquidity effect by conventional methods. The structural identification of the relevant innovations is done by the Cholesky decomposition using the Wold causal ordering: *RRX, NBRX, FF*. The impulse responses calculated with the polynomial Π_1(L) correspond to periods in which the target remained unchanged and represent 179

[1] The sources and definitions of these variables are explained in detail in the data appendix.

observations in the first period (pre-1994 sample) and 152 observations in the second period (post-1994 sample). Similarly, the responses calculated with $\Pi_2(L)$ correspond to periods in which the target was changed and represent 77 observations in the first sample and 20 observations in the second sample.

Conventional lag-length selection criteria (such as Akaike's Information Criterion, AIC) suggest that we use 8 lags and as such, we specified the dynamics of the first state lagged polynomial, $\Pi_1(L)$. However, note that because there are relatively few observations that correspond to periods with target changes, we were forced to restrict the lag length of that state to only one lag. In the experiments that we conducted, this limitation did not affect the rich dynamics that can be computed.

Figure 4 reports the results of these experiments. The left hand side panels display the impulse responses of the federal funds rate to a shock in nonborrowed reserves while the right hand side panels display the responses of nonborrowed reserves to its own shock. The top panels refer to the pre-1994 period while the bottom panels refer to the post-1994. Each panel displays the responses one would obtain from a conventional VAR (solid line) and the two standard deviation error bands (doted lines); the response in the first state (periods when the target remained unchanged, represented by a dashed line and triangle symbols); and the response in the second state (periods when the target is changed, represented by a dashed line and X symbols). For each period, each panel is normalized to display the response to an innovation of identical size.

The results of this experiment are rather clear. For both periods, a conventional VAR would suggest that in response to a positive innovation in nonborrowed reserves (i.e., an unexpected injection of liquidity by the central bank) the federal funds rate will decline significantly for three to four maintenance periods (although the size of the shock in the second period is smaller, it is evident that the funds rate is somewhat less responsive). This is the type of evidence that would suggest a significant liquidity effect. However, during the pre-1994 period in which target changes were not announced, it would appear that the federal funds rate is *less* responsive during periods in which the target was changed than otherwise. Nevertheless, note that the responses in each state mostly fall within the error bands of the conventional impulse response, suggesting that the differential effect is not very important.

In contrast, consider the responses of the federal funds rate in the post-1994 period: the response of the federal funds rate to a shock in nonborrowed reserves in periods in which the target was changed is significantly larger. When there is no change in the target, in response to a one standard deviation shock in nonborrowed reserves, the funds rate declines by no more than 5 basis points. However, if there is a change in the target, the same shock causes a decline in the funds rate of almost 16 basis points or three times as much. To provide some perspective on the magnitude of the announcement effect, consider that to signal a 25 basis point drop in the federal funds rate, the Desk only requires an injection of $3.5 billion over a maintenance period, instead of $11.2 billion (quantities refer to August 2000). In addition, note that nonborrowed reserves return to their steady state level much more quickly after a target change (although this could be in part motivated by the limited dynamics permitted in state two). Consequently, this evidence strongly suggests that the announcement effect is responsible for the differential response in the federal funds rate.

5. Announcements, Expectations and Term Rates

The previous section suggests that the new policy of announcing changes in the funds rate target regiments the formation of expectations in a way that makes open market operations less necessary to signal the new level for the federal funds rate. This section provides evidence on how these announcements regiment the price discovery process in the market for Treasury securities. Because the announcement of a change in the target is often an expected event, we make special emphasis in separating these events into their anticipated and unanticipated components. In particular, we will exploit available data on the market for federal funds futures and the methodology developed by Kuttner (2001) to achieve this goal and study the market's ability to predict policy actions as well as the market's response to surprise policy moves.

5.1 Measuring Market Expectations on Target Changes

Market expectations of changes in the target can be directly computed with data from the federal funds futures market. Specifically, Kuttner (2001) suggests that the surprise component of a target change can be constructed as[2],

$$\tilde{\varepsilon}_\tau = \frac{m_s}{m_s - \tau}\left(f^0_{s,\tau} - f^0_{s,\tau-1}\right) \tag{6}$$

for all but the first and last days in the month. $\tilde{\varepsilon}_\tau$ denotes the surprise component of a target change, m_s denotes the number of days in month s, τ is the day of the month in which the target is changed and $f^0_{s,\tau}$ denotes the spot-month futures rate at date τ of month s over which the average, effective overnight funds rate is computed to price the contract. The expected component of a target change can then be calculated as,

$$E_{\tau-1}(\Delta f^*_\tau) = \Delta f^*_\tau - \tilde{\varepsilon}_\tau \tag{7}$$

were all the variables have been defined above except for Δf^*_τ, which denotes a change in the funds rate target at time τ. Note that $\tilde{\varepsilon}_\tau = -E_{\tau-1}(\Delta f^*_\tau)$ whenever $\Delta f^*_\tau = 0$.

The futures market for federal funds was established in 1988. However, the earliest date for which we have reliable data is May 18, 1989. Consequently, we constructed the series of expectational and surprise components described by equations (6) and (7) for each day (rather than each maintenance period) in the sample May 18, 1989 to August 14, 2000. To begin with, we investigate the ability of the expectational component to predict, one day in advance, changes in the funds rate target. Furthermore, because we are interested in any differences emanating from the February 3-4, 1994 break point, we will split the sample at that date.

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[2] We refer the reader to Kuttner (2001) for a detailed explanation of the workings of this futures market.

More specifically, let $y_t = 1$ if the target was changed in day *t,* and is zero otherwise. Then consider the specification of a binary logistic model that predicts y_t conditional on a vector of explanatory variables, w_t, which will be defined shortly:

$$P(y_t = 1 \mid w_t, \beta) = \frac{\exp(w_t'\beta)}{1 + \exp(w_t'\beta)} \tag{8}$$

where the vector w_t includes a constant term; the dummy variable $d_t^{FOMC} = 1$ if that day corresponds to an FOMC meeting (since most target changes take place after an FOMC meeting), 0 otherwise; the variable $\left|E_{t-1}(\Delta f_t^*)\right|$ which we use in its absolute value form on account that we are solely interested in predicting target changes, irrespective of their sign; and the variable $d_t^{FOMC}\left|E_{t-1}(\Delta f_t^*)\right|$ to allow for the possibility that expectations corresponding to days of FOMC meetings may be more strongly linked to the outcome of the meeting. The estimates for each sample are reported in Table 1.

Table 1 clearly indicates that forecasting changes in the target one day in advance has become easier since 1994. Not only is the model fit substantially higher (McFadden's R^2 increases from 0.07 to 0.8) but also the predictive power of the model improves significantly: in the first subsample, the model is essentially incapable of distinguishing when events will happen (only 7.7% percent of events are properly predicted). However, in the second sample 80% of target changes are correctly predicted, in spite of the fact that the proportion of target changes to total observations is significantly smaller (26:1206 in the first subsample versus 20:1682 in the second subsample). These results unequivocally suggest that the market has a better understanding of when target changes are *likely to happen*. However, note that we are not saying that the market now has a better understanding of when events *did happen*, since we are not making a judgment about the Fed's ability to signal new changes in the target via open market operations.

5.2 Term Structure Responses to Fed Announcements

The decomposition of target changes into their expectational and surprise components (described in expressions 6 and 7), allows us to ask whether or not the policy of announcing these changes has made any difference in the manner term rates react. One way to proceed is to ask whether rates respond at all to predictable policy actions, in a manner similar to Cook and Hahn (1989) and Kuttner (2001). In particular, consider regressing a Treasury rate on the two components of a target change, namely

$$\Delta R_\tau = \alpha + \beta_1 E_{\tau-1}(\Delta f_\tau^*) + \beta_2 \tilde{\varepsilon}_\tau + u_\tau \tag{9}$$

where *R* denotes the yields on the 3-, 6-, and 12-month Treasury bills, 2-, 5-, and 10-year Treasury notes, and 30-year Treasury bonds (we will often refer generically to all these securities as "Treasury notes") and the remaining variables have been defined in expressions (6) and (7). Expression (9) is estimated on days in which the target was changed only, over the samples 5/18/1989 – 2/3/1994 and 2/4/1994 – 8/14/2000. These regressions can be seen as complementing the regressions reported in Table 3 in Kuttner (2001) and are reported here in Table 2.

Despite having a small number of degrees of freedom (there are 25 target changes in the pre-1994 sample and 20 in the post-1994 sample), the parameters are relatively precisely estimated. The obvious patterns that emerge from Table 2 are twofold. First, we replicate the general result in Kuttner (2001) that, as the maturity of the Treasury note increases, the reaction to the surprise component of a target change diminishes. However, notice that the coefficient on this component is statistically not different from the canonical value of 1 for all maturities up to five years. Second, the pre-1994 sample is characterized by statistically significant and economically sizeable responses to the *expected* component of a target change (except for the 10- and 30-year notes) while for the post-1994 sample these responses are uniformly statistically and economically indistinguishable from zero. This second piece of evidence confirms the results reported in Table 1: it appears that markets have been able to predict changes in the target much more accurately since 1994. Furthermore, the responses displayed by the regressions in

Table 2 suggest that term rates react in a manner that is closely consistent with the rational expectations hypothesis on days when the target is changed.

5. 3 The Timing Hypothesis and the FOMC Schedule

The final experiment that we consider contemplates two issues simultaneously. First, we explore the manner in which the FOMC schedule regiments the formation of expectations about future target changes. In other words, do changes in the target executed outside regularly scheduled FOMC meetings carry more weight? Since 1994 and up to the end of our sample (8/14/2001), the Fed has only changed the target outside an FOMC meeting once. Secondly, we examine what Kuttner (2001) labels as the "timing hypothesis," which we explain succinctly as follows. Rudebusch (1995) documents that the Fed typically changes the target in a series of 25 basis point increases/decreases in the same direction and that the Fed rarely reverses the general trend of these changes. Consequently, when we calculate the response of term rates (particularly securities with longer maturities) to the surprise component of a target change, it is entirely possible that the market timed the target change incorrectly but nevertheless, widely anticipated that change sometime in the near future. Thus, the main advancement or postponement of anticipated rate changes will have a smaller effect on term rates than actions that truly indicate a reversal in the policy stance.

A simple way to explore both of these issues simultaneously consists in estimating a regression on a sample that contains dates in which the target was changed exclusively, similar in nature to the regression in expression (9). However, in addition we consider the following two variables: the dummy variable d_τ^{FOMC} which is defined above and indicates whether the τ^{th} change in the target corresponded with an FOMC meeting or not; and the dummy variable d_τ^{SWITCH} which takes the value of one if the target change at time τ reverses the direction on the target change at time τ-1, 0 otherwise (note that the time index τ now indicates dates of target changes exclusively rather than calendar days). Interacting these two additional variables multiplicatively in expression (9), yields

$$\Delta R_\tau = \alpha_0 + \alpha_f d_\tau^{FOMC} + \alpha_s d_\tau^{SWITCH} + \beta_1^0 E_{\tau-1}(\Delta f_\tau^*) + \beta_1^f d_\tau^{FOMC} E_{\tau-1}(\Delta f_\tau^*) + \\ \beta_1^s d_\tau^{SWITCH} E_{\tau-1}(\Delta f_\tau^*) d_\tau^{SWITCH} + \beta_2^0 \tilde{\varepsilon}_\tau + \beta_2^f d_\tau^{FOMC} \tilde{\varepsilon}_\tau + \beta_2^s d_\tau^{SWITCH} \tilde{\varepsilon}_\tau + u_\tau \tag{10}$$

Thus, this parametrization measures the response of the term rate R_τ to, among other effects, the surprise component of a target change realized: (1) at an FOMC meeting (measured by $\hat{\beta}_2^0 + \hat{\beta}_2^f$); (2) *outside* an FOMC meeting (measured by $\hat{\beta}_2^0$); (3) at an FOMC meeting which signals a reversal in the policy stance (measured by $\hat{\beta}_2^0 + \hat{\beta}_2^f + \hat{\beta}_2^s$); and (4) *outside* an FOMC meeting in addition to signaling a reversal in the policy stance (perhaps the strongest signal the Fed can send, measured by $\hat{\beta}_2^0 + \hat{\beta}_2^s$).

Table 3 reports the estimates of expression (10) over the sample 5/18/1989 – 8/14/2000 (note that there are an insufficient number of target changes outside FOMC dates and policy stance reversals to afford sufficient degrees of freedom in estimating expression (10) over pre and post 1994 samples). The results of this experiment are quite striking and perhaps justify why it is often hard to find that the federal funds rate has any effect on long-term rates. A target change executed at a regularly scheduled meeting that is consistent with the general direction of the policy stance, has no statistically significant impact on Treasury rates at any maturity. However, if that same target change is announced outside an FOMC meeting, that change will still have a significant impact, although this impact substantially declines as the maturity of the Treasury note increases (from almost a value of 0.7 to below 0.2). In contrast, when the Fed reverses the direction followed in previous target changes (a reversal of the policy stance), Treasury notes display a very sizeable response, often times surpassing the canonical value of 1. In particular, when the reversal comes at an FOMC meeting, as the maturity of the note increases, the response increases from 1.12 for the three-month T-bill up to 1.83 for the five-year T-note and then declines to 1.48 and 0.98 for the ten- and thirty-year T-notes. A similar pattern emerges if the reversal is done outside the FOMC meeting although the responses are even more dramatic: the peak at the five-year T-note mark is now 2.46. This means that a 25 basis points increase in the funds rate will cause an increase of approximately 62 basis points in the five-year Treasury note.

These results shed light on a number of important issues. First, they demonstrate the importance of the FOMC schedule in the manner markets form expectations on future changes in the federal funds rate. Second, they show that term rates immediately adjust to new information (characterized here by policy stance reversals and outside of FOMC announcements) in a manner consistent with the rational expectations hypothesis. However, once this information is incorporated into the term structure, subsequent, regularly scheduled, and anticipated announcements, have little impact on term rates. This observation perhaps explains the poor results commonly obtained in the literature on tests of the rational expectations hypothesis (see Rudebusch, 1995 for a survey).

6. Conclusion

The February 3-4, 1994 FOMC meeting concluded with one of the most significant procedural changes in the Federal Reserve in recent times – the decision to publicly announce changes in the funds rate target immediately after the event. This procedural modification constitutes a significant departure from the recalcitrant secretive behavior that had characterized traditional central banking. Among the reasons that would justify this revolution, it is natural to conjecture that the new policy affords better and more precise control of the overnight rate and better communication on future policy moves: in essence, better control of long rates by manipulating expectations more adroitly.

The daily conduct of open market operations is a complex process fraught with a variety of technical factors unrelated to the stance of monetary policy. By announcing changes in the target, the Desk has been able to communicate to the market the new level of the desired federal funds rate with a smaller volume of open market operations than was characteristic prior to 1994 – the Pavlovian response that we document in Section 4. Traders have placed increased credibility on the Fed's commitment to maintain the funds rate on target, a notion that is cemented by the clarity that the regular announcement of FOMC outcomes provides.

Ultimately the goals of monetary policy require that the Fed be successful in guiding the market's expectations of future policy moves, and thus, that there be some synchronicity in longer maturity rates. The evidence we present in this front demonstrates that since 1994, the announcement and the FOMC schedule allow markets to better anticipate the timing and the nature of future policy moves. To be clear, we are not arguing that prior to 1994, the Fed was unable to signal the market what its preferred funds rate objective was. However, the evidence that we present strongly suggests that term rates react strongly when the Fed initiates a policy stance reversal – a response that is entirely consistent with the rational expectations hypothesis and with a better understanding on how the Fed implements policy.

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Data Appendix

Reserves Data

Source: Release H. 3, Table 4, "Aggregate Reserves of Depository Institutions (adjusted for changes in reserve requirements – SA)," Federal Reserve Board

Units: Millions of Dollars

Variables: Required Reserves, Nonborrowed reserves plus extended credit, total reserves, and adjusted plus seasonal borrowing (NSA).

Federal Funds Rate

Source: Release H. 15, "Selected Interest Rates," bi-weekly ending on a Wednesday. Federal Reserve Board.

Units: in percent.

Definition: weighted average of reported rates at which different amounts of the day's trading through New York brokers occurs.

Interest Rate Data

Source: Release H. 15, "Selected Interest Rates," daily data. Constant maturity rates.

Units: in percent

Variables: 3-, 6-, and 12-month Treasury bills, 2-, 5-, and 10-year Treasury notes and, 30-year Treasury bonds.

FOMC meetings

Source: Federal Reserve Board, FOMC Calendar

Table 1. The Predictive Power of the Federal Funds Futures Market

Binary Logit Estimates

Model:

$$P(y_t = 1 \mid w_t, \beta) = \frac{\exp(w_t'\beta)}{1+\exp(w_t'\beta)} \tag{8}$$

Regressors in w_t:

- constant term
- d^{FOMC}
- $\left|E_{t-1}(\Delta f_t^*)\right|$
- $d_t^{FOMC}\left|E_{t-1}(\Delta f_t^*)\right|$

	Sample	
	5/18/1989 – 2/3/1994	**2/4/1994 – 8/14/2000**
N. Obs $y_t = 1$	26	20
N. Obs $y_t = 0$	1206	1682
McFadden R^2	0.07	0.80
Specificity	100%	99.9%
Sensitivity	7.7%	80%
Avg. Log-Likelihood	-0.095	-0.013

Notes: *McFadden* R^2 is the likelihood ratio index computed as $1 - l(\hat{\beta})/l(\tilde{\beta})$ where $l(\tilde{\beta})$ is the restricted log likelihood. This is the analog to the R^2 reported in linear regression models and is a number between 0 and 1. *Specificity* refers to the fraction of $y = 0$ observations correctly predicted. *Sensitivity* refers to the fraction of $y = 1$ observations correctly predicted.

Table 2. The Response of Term Rates to the Components of a Target Change

$$\Delta R_t = \alpha + \beta_1 E_{t-1}(\Delta f_t^*) + \beta_2 \tilde{\varepsilon}_t + u_t \tag{9}$$

R_t Maturity	β_1 Response to Anticipated *Pre-1994*	*Post-1994*	β_2 Response to Unanticipated *Pre-1994*	*Post-1994*
3-month	0.4*	0.0	0.8**	0.8**
	(0.2)	(0.1)	(0.2)	(0.2)
6-month	0.5*	0.0	0.8**	0.6*
	(0.2)	(0.0)	(0.1)	(0.3)
12-month	0.4*	0.0	0.9**	0.6*
	(0.2)	(0.1)	(0.2)	(0.3)
2-year	0.4*	0.0	0.7**	0.5
	(0.2)	(0.1)	(0.1)	(0.3)
5-year	0.4*	0.0	0.6**	0.4
	(0.2)	(0.1)	(0.1)	(0.4)
10-year	0.3	0.0	0.4**	0.3
	(0.2)	(0.1)	(0.1)	(0.3)
30-year	0.3	-0.1	0.3*	0.2
	(0.2)	(0.1)	(0.1)	(0.2)

Notes: expression (9) is estimated only on days in which the target was changed. There are 25 observations for the pre-1994 (5/18/1989 – 2/3/1994) sample, and 20 observations for the post-1994 (2/4/1994 – 8/14/2000) sample. Standard errors in parenthesis. **(*) indicates significant at the 99% (95%) confidence level.

Table 3. The Timing Hypothesis and the FOMC Schedule

$$\Delta R_\tau = \alpha_0 + \alpha_f d_\tau^{FOMC} + \alpha_s d_\tau^{SWITCH} + \beta_1^0 E_{\tau-1}(\Delta f_\tau^*) + \beta_1^f d_\tau^{FOMC} E_{\tau-1}(\Delta f_\tau^*) + \beta_1^s d_\tau^{SWITCH} E_{\tau-1}(\Delta f_\tau^*) d_\tau^{SWITCH} + \beta_2^0 \tilde{\varepsilon}_\tau + \beta_2^f d_\tau^{FOMC} \tilde{\varepsilon}_\tau + \beta_2^s d_\tau^{SWITCH} \tilde{\varepsilon}_\tau + u_\tau \quad (12)$$

Timing	Maturity 3-month	6-month	1 year	2-year	5-year	10-year	30-year
At FOMC	0.36 (0.32)	-0.02 (0.32)	0.09 (0.34)	-0.15 (0.35)	-0.22 (0.38)	-0.23 (0.34)	-0.08 (0.31)
Outside FOMC	0.67** (0.08)	0.68** (0.08)	0.68** (0.09)	0.55** (0.09)	0.41** (0.10)	0.25** (0.09)	0.18* (0.08)
At FOMC+ SWITCH	1.12* (0.55)	1.44** (0.55)	1.28* (0.59)	1.72** (0.59)	1.83** (0.65)	1.48* (0.59)	0.89 (0.53)
Outside FOMC + SWITCH	1.44* (0.64)	2.15** (0.64)	1.86** (0.69)	2.42** (0.69)	2.46** (0.76)	1.96 (0.68)	1.15 (0.62)
R^2	0.65	0.67	0.62	0.56	0.42	0.33	0.25

Notes: Standard Errors in parenthesis. **(*) indicates significant at the 99%(95%) confidence level.

Calculation of the Coefficients:

- At FOMC: $\beta_2^0 + \beta_2^f$
- Outside FOMC: β_2^0
- At FOMC + SWITCH: $\beta_2^0 + \beta_2^f + \beta_2^s$
- Outside FOMC + SWITCH: $\beta_2^0 + \beta_2^s$

Figure 1 - Adjusted Required Reserves of Depository Institutions

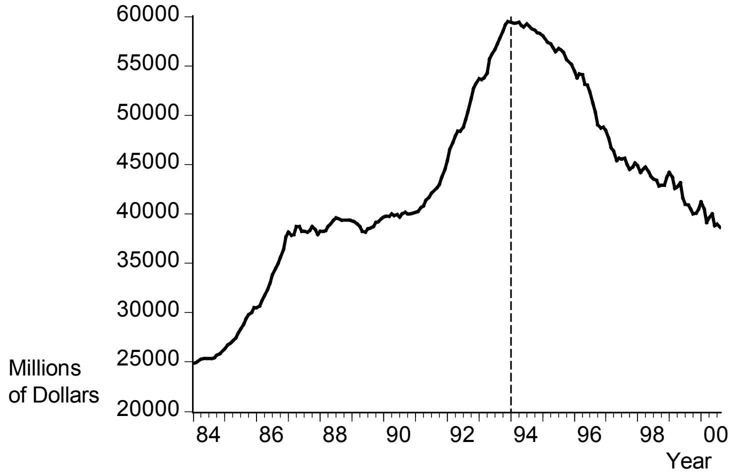


Figure 2 - Ratio of Non-Transaction to Transaction Deposits

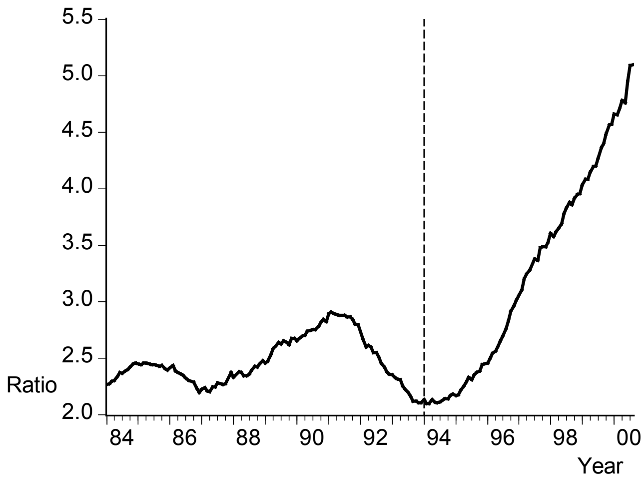


Figure 3 - Adjusted Borrowing from Federal Reserve Banks

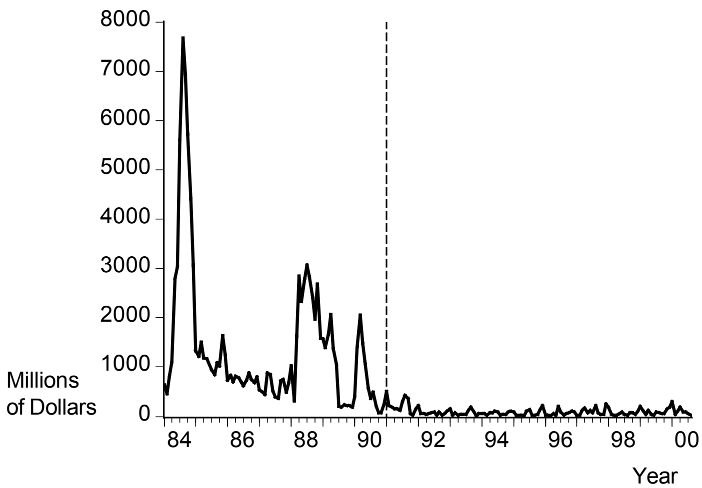
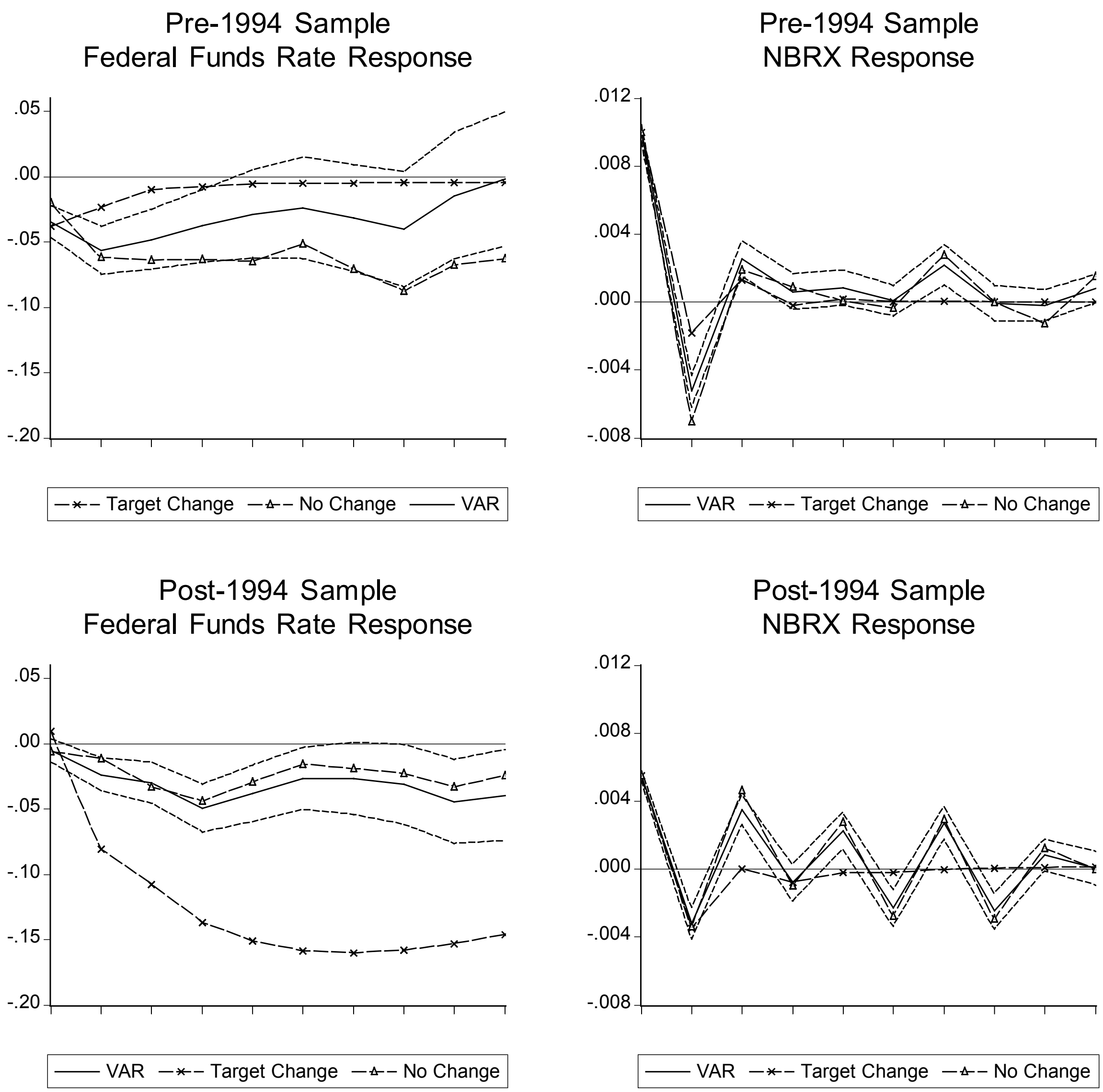


Figure 4 - Measuring the Announcement Effect



Notes: Bi-weekly data on RRX, NBRX and FF. Pre-1994 sample: 4/25/1984 – 2/4/1994. Post-1994 sample: 2/4/1994 – 8/14/2000. Impulse Responses labeled "VAR" are calculated from a conventional VAR with 8 lags. Responses labeled "Target Change" are calculated from the two-state VAR and the state corresponding to periods in which the target was changed. Similarly, responses labeled "No Change" are calculated from the state corresponding to periods in which the target was not changed.