Exchange Rates and FOMC Days

Michael Melvin*
Arizona State University

*Department of Economics, Arizona State University, Tempe, AZ 85287-3806, Phone: 480-965-6860, email: mmelvin@asu.edu.

Helpful comments were received from seminar participants at the Econometric Society winter meetings, Deutsche Bundesbank, Bank for International Settlements, University of Frankfurt, University of Freiburg, University of Miami, U.C. Santa Cruz, U.C. San Diego, and University of Warwick. Patricia Ramirez contributed to the early stages of this paper. Able research assistance was provided by Eugenio Dante Suarez. This paper was developed while the author was visiting UCSD. He thanks the faculty and staff for providing a productive environment for work and discussion of related issues.
ABSTRACT

FOMC meeting days provide a natural laboratory for exploring the effects of policy uncertainty and learning on exchange rate determination. Intradaaily mark/dollar exchange rates are employed for 10 FOMC meetings. The meetings examined are the first 10 following the February 1994 change in policy where the meeting outcome is announced after meetings end. A reasonable hypothesis is that the meeting outcomes are price-relevant public information associated with a switch to an “informed-trading state.”

A markov-switching model is used to estimate the time of informed trading. The data suggest that on most days, there is a switch to the informed-trading state during the time of the meeting, well before the end of the meeting. An extensive search of public news indicates that the informed trading cannot be explained as the response to public information.

An ordered probit model of the bid-ask spread is estimated as a function of the probability of being in the informed trading state. The estimation results indicate that the greater the probability of being in the informed trading state, the wider spreads. This is consistent with dealers protecting against adverse selection in quoting.

The evidence indicates that traders are adjusting positions on more than just public news during FOMC meetings. An interesting question is why such positioning does not occur earlier in the morning prior to the meeting or on a prior day. A remaining puzzle is what causes the switch to the informed-trading state during meeting time.
I. INTRODUCTION

In 1994, the FOMC began announcing changes in the target for the federal funds rate immediately following meetings. Prior to this time, one had to infer policy changes from open market operations and interest rate changes. During the period of February 1994 to March 1995, the federal funds rate target was changed seven times, with six of the changes occurring at regularly scheduled meetings.\(^1\) Prior to each meeting, survey evidence indicates that market participants believed that the federal funds rate would rise, if changed. These days provide a natural laboratory for the study of policy uncertainty and learning on exchange rate dynamics.

The particular focus of our study is on examining the behavior of exchange rates on days when a major policy meeting is known to occur and a major policy target, considered to be a fundamental determinant of exchange rates, may be changed. Economists have traditionally thought of models with homogeneous agents where the meeting outcome provides public information (news) that is shared equally by all agents. In this framework, exchange rates shift when the news is received at the meeting end. Microstructure models of financial markets suggest that on such days we may find exchange rates experiencing shifts due to information-based trading of both the public and private type and such shifts may occur prior to the meeting end and the news of the outcome. Specifically, the literature suggests the exploration of the following hypotheses: a) Strategic behavior by informed traders results in the revelation of their information to the market prior to the meeting end and b) Bid-ask spreads change in response to the probability of adverse selection associated with quoting to the informed. We shall see that the evidence supports both of these hypotheses for the FOMC days considered in our study.

---

\(^1\) On April 18, 1994 the federal funds target was increased outside a regularly scheduled meeting.
The study is divided into three sections. Section II examines the evidence on intraday exchange rate changes via a switching-regime model to infer the time when informed position-taking occurs. The model estimated allows us to identify the time of day when the exchange rate moves from a regime of small, random changes consistent with liquidity trading toward a regime of large, volatile changes consistent with the presence of informed traders taking positions in anticipation of the FOMC meeting outcome. Ignoring brief switches of only a few minutes, estimates of the time of position taking average 3 hours and 5 minutes prior to meeting end across the sample meeting days. A careful review of public news on these days indicates that few of the switches to the informed-trading state can be explained by public news. This leaves position-taking based on private information as the likely cause of the switch to the informed trading state.

The third section of the study examines the effect of regime switches, from a state dominated by liquidity trading to one dominated by informed trading, on the behavior of the bid-ask spread. If informed traders are taking positions based on expectations of FOMC policy changes, we should expect dealers to widen quoted spreads to guard against the likely adverse selection associated with quoting to the informed. An empirical model of the spread incorporating the probability of being in the state with informed trading is estimated. Overall, spreads widen with higher probabilities of being in the state with active informed traders.

The fourth section of the paper offers a summary and conclusion.
II. ANTICIPATION OF POLICY ACTION

Monetary policy effects on exchange rates have a long history in the empirical international finance literature. Traditionally, such analyses have emphasized macro-oriented models like the monetary model of the exchange rate and utilized low frequency data. There have also been important studies using an event methodology to infer the effects of monetary policy actions on exchange rates. For instance, recently Bonser-Neal, Roley, and Sellon (1998) estimated models of the effect of FOMC federal funds rate target changes on spot and forward exchange rates. Their analysis focused on the change in exchange rates from the day before to the day after FOMC meetings. Exchange rates were seen to respond significantly to changes in federal funds rate targets. The common interpretation of such results is that the FOMC meeting outcomes provide news to the market that is price-relevant and reflected in the consequent change in exchange rates.

Our analysis takes more of a microscopic look at this issue to examine whether the meeting end is, in fact, providing news to the market that results in exchange rates changing at that time. Why might we expect any other dynamic for exchange rates? If we think of the foreign exchange market as a market with asymmetrically-informed traders in the spirit of Kyle (1985), then we may expect informed traders to take positions during the meeting in anticipation of the policy outcome. Such behavior does not require any information leaks from official sources or unethical behavior, but reflects the informed opinion of the likely action occurring at meeting's end. Such opinions might be formed on the basis of activities taking place at the Board of Governors during the meeting, inventory position changes inferred from counterparties occurring during the meeting, or some other source of relevant information that stimulates changes in quoted prices on currencies. We will let the data

---

2 Recently, a model intended for the foreign exchange market has been advanced in Lyons (2001) and Evans and Lyons (2002).
reveal whether we should view the meeting outcomes as news or whether there is an earlier
adjustment of the market prior to the end of FOMC meetings.

II.A. Modeling Strategy

In order to estimate the time when informed traders take positions on FOMC days, we will estimate a version of a modeling strategy proposed by Hamilton (1989). The analysis is motivated by the belief that the market is populated by heterogeneously informed traders. Specifically, we assume that there are three kinds of traders: A risk neutral informed trader, who anticipates the final value of the foreign currency; uninformed liquidity traders who trade randomly; and market makers who absorb the order flow while earning zero expected profits. The model is a simple variation of Kyle (1985) adapted for estimation in a switching-regime framework.

Let \( u_t \) be the position of the liquidity trader at time \( t \). Time \( t \) runs from 0 to 1. The order flow of the liquidity trader is \( \Delta u_t = u_t - u_{t-1} \). This order flow is distributed normally with mean zero and variance \( \sigma_u^2 \). The informed trader receives a signal of the final value of the exchange rate, denoted \( \nu \), at time \( t_0 \). The position of the informed trader at time \( t > t_0 \) is denoted by \( x_t \) and the order flow is equal to \( \Delta x_t \) (where \( \Delta x_t = x_t - x_{t-1} \)). The exchange rate at time \( t \) is \( S_t \). Equilibrium is described by the following functions for informed trading volume and exchange rate change:

\[
\Delta x_t = \mu I_{t > t_0} (\nu - S_t)_{t-1} \quad (1)
\]

\[
\Delta S_t = \lambda_1 (\Delta x_t + \Delta u_t) \quad (2)
\]

where \( \mu \) measures the intensity with which the informed trader trades on the basis of his/her private information; and \( 1/\lambda_1 \) measures the depth of the market (with small \( \lambda_1 \) corresponding to a deep market).

Substituting for informed-trader volume in the exchange rate change equation, we have:
\[ \Delta S_t = \delta_t (v - S_{t-1}) + \epsilon_t \]  

where \( \epsilon_t = \lambda_t \Delta \alpha_t \), distributed normally with mean zero and variance \( \lambda_t^2 \sigma_\alpha^2 \); and \( \delta_t = \lambda_t \mu_t \).

The change in the exchange rate is affected by both liquidity and informed orders. However, the informed traders are assumed to enter the market for short intervals of time so that the normal state is one of liquidity trading.

The model suggests the interpretation of the exchange rate process following two states. State 1 is the usual state of liquidity-motivated trades or \( \Delta S_t = \epsilon_t \), where the exchange rate moves randomly with a relatively small variance. State 2 is the state containing the informed trades as given by equation (3), where the exchange rate change may be characterized by relatively large swings and variance is higher. We assume that there exists an unobserved state variable \( s_t \) that takes on the value one or two when the observed change in the exchange rate is drawn from a \( N(\mu_1, \sigma_1^2) \) distribution or a \( N(\mu_2, \sigma_2^2) \) distribution, respectively. Following Hamilton, we postulate that the unobserved state variable evolves as a Markov chain:

\[
\begin{align*}
    p(s_t = 1 | s_{t-1} = 1) &= p_{11} \\
    p(s_t = 2 | s_{t-1} = 1) &= 1 - p_{11} \\
    p(s_t = 1 | s_{t-1} = 2) &= 1 - p_{22} \\
    p(s_t = 2 | s_{t-1} = 2) &= p_{22}
\end{align*}
\]

We expect the general state of the market to be dominated by liquidity trading so that state 1 normally prevails and \( p_{11} \) should be larger than \( p_{22} \).

For details regarding the estimation of switching-regime models, see Hamilton (1994). Here we briefly sketch the procedure employed. Six population parameters are sufficient to describe the distribution of \( S_t \) given \( s_t \), the distribution of \( s_t \) given \( s_{t-1} \), and the unconditional distribution of the state of the first observation. The six parameters are:

\[ \theta = (\mu_1, \mu_2, \sigma_1, \sigma_2, p_{11}, p_{22})' \]

Given estimates of the \( \theta \) parameters, one can calculate the probability that the process was in a particular state \( s_t \) at time \( t \) on the basis of the information through \( t \). Our goal is to
apply this procedure to identify shifts in regime that are consistent with the advent of informed trading on FOMC meeting days.

II.B  Data to be Analyzed

Model estimation requires data on exchange rates and dates and meeting times for the FOMC. The exchange rate data are derived from the tick-by-tick indicative quotes on the German mark price of the U.S. dollar (DEM/USD) from Reuters. We use the midpoint of the bid and ask prices that are time-stamped to the second they appeared on the Reuters screen. The last quote of each five-minute interval is used to create a data set of five-minute periodicity.

Table 1 lists the FOMC meeting days studied along with the start and end times, the expected interest rate change and the actual change. We choose a period where there is a clear expectation of FOMC rate increases. Each meeting was approached with the expectation that the outcome would be either a rise in the federal funds rate or else no change. There was a zero probability of a rate decrease. This creates an asymmetric distribution for the expected change in the exchange rate.

Information on meeting times was taken from Reuters' Money Market Headline News. The "headline news" screen reports activity of interest to traders and reflects the time that traders would see reports of the meeting times on their monitors. In addition, we also list the official ending times as reported in the FOMC meeting minutes. While one might expect that the news service announcements of a meeting end should follow the official ending times, Table 1 indicates that on three meeting days, the news service reports lead the official meeting time ending. We have no explanation for the differences between official meeting times and the Reuters reports except for the fact that the Fed spokesperson making the announcement of the meeting end typically appears before the press well after the official end. Since we believe that the Reuters reports will coincide more closely with information
available to market participants, we focus on these times rather than the official ending
times in our empirical work below.

The fifth column of Table 1 gives the magnitude of the expected change in the
exchange rate (as reported in the *Wall Street Journal*) while the sixth column reports the
actual change. For eight of the ten meeting days, the *Wall Street Journal* reports that the
general outlook in the market was an expectation of a Fed interest rate hike.4

II.C. Estimates of Position-Taking Time

The model presented in the previous section is estimated with the goal of identifying
points in time when regime switches from state 1 to state 2. Estimation is carried out
separately for each individual meeting day and estimation time runs from 8:00-21:00 GMT.5
Table 2 reports the estimation results. The means of both states are generally insignificantly
different from zero but the variance of state 2, when informed trading is presumed to have
occurred, is generally estimated to be substantially higher than that of state 1. We expect
liquidity trading to dominate most periods so that \( p_{11} \) should exceed \( p_{22} \). In all but one day,
the estimate of \( p_{11} \) exceeds that of \( p_{22} \). Estimation for December 20, 1994 yields an estimate
of \( p_{11} \) that is less than \( p_{22} \). However, as will become apparent shortly, this pre-Christmas day
when no Fed policy actions occurred is unlike the others. The exchange rate traded in a
narrow range all day and the data are essentially consistent with only 1 state.

The Markov-switching models were estimated to provide inference regarding the
timing of informed trading activity. Figure 1 contains plots of the exchange rate returns
along with estimates of the state that prevails at each time period. If the outcome of FOMC

---

3 The data were obtained from Olsen & Associates in Zurich.
4 For an economic model of federal funds rate target expectations see Jorda and Hamilton
(1999). They provide a model of the federal funds target as a marked point process where
they predict both the "points" at which the target rate is changed and the "marks" or size of
change.
5 Estimation was carried out by modifying GAUSS files generously provided on James
Hamilton's web site that use numerical optimization to maximize the likelihood function.
Hamilton (1994) discusses issues related to estimation.
meetings provide a public information signal shared by all, we might expect to see exchange rate shifts at the meeting end and no other obvious patterns in informed trading activity during the day. As seen in Figure 1, there is much evidence of regime shifts consistent with informed trading prior to meeting end. Let us characterize the regime-switching patterns for each day:

**February 4, 1994**: There is a shift to state 2 prior to the meeting start which is followed by a return to state 1 during the meeting and then at the meeting end, there is another shift to state 2 consistent with the outcome being news to the market. The shift to state 2 in the U.S. morning is associated with the employment report that was released at 13:30 GMT that day. The slower-than-expected job growth report led some Fed watchers to conclude that the FOMC would leave rates unchanged. In fact, following the employment data release Merrill-Lynch issued a bulletin stating that "Weather-distorted jobs report delays Fed tightening." Of course, that forecast turned out to be wrong as the FOMC raised rates later that morning.

**March 22, 1994**: A switch to regime 2 occurs during the meeting followed by a return to state 1 prior to meeting end and then at meeting end, there is another brief switch to regime 2. A review of Bloomberg and Reuters reports reveals no significant news prior to the meeting end.

**May 17, 1994**: There is a switch to regime 2 following the meeting start, followed by a brief return to regime 1 prior to the meeting end and then at the meeting end there is another return to regime 2. A review of Bloomberg and Reuters reports reveals no significant news prior to the meeting end.

**July 6, 1994**: There is a brief switch to regime 2 in the London morning. One hour after the meeting starts, there is a switch to regime 2 for about an hour followed by a return to regime 1 for another hour. During the last two hours of the meeting, regime 2 is again established followed by a return to regime 1 around the meeting end. The early European morning regime shifts are likely associated with the German unemployment news release and a
Bundesbank repo rate decrease. A review of Bloomberg and Reuters reports reveals no significant news after these two events.

*August 16, 1994:* There is a switch to regime 2 about 1.5 hours prior to the meeting end and this regime persists until about 1.5 hours after the meeting end. A review of Bloomberg and Reuters reports reveals no significant news prior to the meeting end.

*September 27, 1994:* There is a switch to regime 2 shortly after the meeting start followed by a return to regime 1 for about an hour. Regime 2 is again observed for about the last 2 hours of the meeting. About 30 minutes after the meeting conclusion, there is a shift back to regime 1. The early shift to regime 2 after the meeting start may be associated with the release of news that consumer confidence fell for the third month in a row.

*November 15, 1994:* There is a switch to regime 2 about 1 hour after the meeting starts and regime 1 does not return until about 1 hour after the meeting end. While retail sales news was released at 13:30 and industrial production news was released at 14:15, it appears that there was no significant market reaction. In fact, the next day *The Wall Street Journal* reported that "A smorgasbord of economic statistics came and went in the morning, but traders largely shrugged off the news."

*December 20, 1994:* On this day when no action was taken the data are relatively uninformative regarding differences in states. The exchange rate trades within a narrow range with relatively small variance all day. While state 2 is identified as the state that exists for most of the day, the evidence is more consistent with one state prevailing over the day.⁶ The next day, *The Wall Street Journal* confirmed this view by reporting that "The dollar was mixed in sleepy pre-holiday dealings yesterday, unmoved by news.....The Fed stayed with no rate increase ...Everybody just breathed a sigh of relief and went back to sleep."

---

⁶ Note in Table 2 that this is the only day where an estimated mean is significantly different from zero. The classification of a few observations into state 1 occurs on the basis of both mean and variance shifts.
February 1, 1995: The switch to regime 2 at the meeting end is consistent with the meeting outcome being news to the market following a day characterized by exchange rate dynamics consistent with liquidity trading.

March 28, 1995: Aside from a brief switch to regime 2 during the London morning, there are 3 brief switches to regime 2 during the meeting period with a return to regime 1 more than 2 hours prior to the meeting end. Consumer confidence news was released at 14:00 and there were no other significant news announcements during the day.

This research began with the expectation of finding results similar to those for February 1, 1995 for each FOMC meeting day. We expected a shift to the informed trading state on the basis of the news of the FOMC policy decision. However, the data suggest that traders are adjusting positions on more than just public news on meeting days. The evidence is consistent with position taking largely during the meeting along with some later trading associated with the news content at the meeting end. Our results indicate that FOMC meetings are, indeed, associated with shifts in regime beyond that just coming from the meeting outcome or other public news. While we can rule out other kinds of public information being associated with such meeting-time shifts, exactly what is causing the shifts is, of course, unknown. Furthermore, it is puzzling that such shifts occur during the meetings rather than earlier in the morning prior to meetings or even on prior days. The estimation results would be consistent with intra-meeting information leaks from the FOMC, rumors circulating in the market, and/or traders reading information content into the goings-on around the Fed during meetings. It is known that there was a period when Fed-watchers thought the size of Alan Greenspan’s briefcase on meeting days was informative in that a thin briefcase signaled no action and a thick briefcase signaled action. Given the lengths to which the market may go to distill information in noisy signals coming from briefcase size, coffee or restroom breaks, or other seemingly silly signals, one cannot rule out that market participants are treating some seemingly innocuous activity as informative. The author
makes no claims with regard to exactly what kind of information is driving the estimation results.

II.D. Evidence from a Control Sample

In order to see if the exchange rate dynamics just reviewed are, indeed, due to FOMC meetings on those days, a control sample is examined. If the exchange rate dynamics on non-FOMC days are much like those observed on FOMC days, then we would question the foregoing interpretation of private-information-based trading occurring during the meeting as suggested by the results reviewed so far. Specifically, we match each FOMC day with the same day of the week in the week following each meeting. The control sample, then, will control for any day-of-the-week effects and will allow an examination of the exchange rate evidence for non-FOMC days compared to meeting days. The focus should be on what happens relative to the usual time of FOMC meetings.

Markov-switching models were estimated for each of the control days. To conserve on space, model estimates and plots of the exchange rate returns and associated estimated state variables are not shown. Instead, a summary of each day is provided. Of particular interest is whether there is evidence of a switch to state 2 after 14:00 (13:00 for days on daylight saving time) that cannot be explained by public news arrival. If so, then we would have to conclude that the exchange rate dynamics for FOMC days are really no different than any other days. However, if the control day switches to state 2 are explained by public news arrival and/or switch times occur outside the usual FOMC meeting times, then the evidence for FOMC days may be considered as consistent with private-information-based trading related to the meeting.

February 11, 1994: There is a switch to state 2 at 12:15 for which no news is apparent. However, this switch lags German retail sales news. There is another switch to state 2 at
13:30 associated with the U.S. PPI and retail sales releases. No state 2 switches occur during typical FOMC meeting time.

March 29, 1994: There is a switch to state 2 at 15:30 associated with U.S. consumer confidence news that lasts for about an hour. Then at 18:05, there is another switch to state 2 that lasts for 20 minutes. This switch comes right after Bloomberg reports Fed Governor Lawrence Lindsey is giving a speech where he states that the Fed should not have to raise interest rates as much in the future as it has in previous inflation-fighting episodes because of the swift action taken by the Fed nowadays.

May 24, 1994: There is one switch to state 2 at 15:50 that lasts for five minutes. This one burst of dollar appreciation is associated with a speech by U.S. Trade Representative Kantor where he states that the U.S. and Japan have ended a three-month impasse in trade negotiations. Earlier, Bloomberg had reported that some traders were awaiting Kantor’s press conference before trading dollars.

July 13, 1994: A switch to state 2 occurs at 10:45 for 10 minutes associated with a Bundesbank repo rate cut. Then at 12:40 another switch occurs for 35 minutes following the German wholesale price release. Then at 13:30 another switch that persists for about 3.5 hours results from the U.S. CPI news followed by retail sales news. Finally, at 19:25 another switch occurs that lasts for 45 minutes. This appears to be due to the announcement that U.S. currency would be redesigned to thwart counterfeiting (interestingly, the dollar briefly depreciated upon this news).

August 23, 1994: A switch to state 2 occurs at 12:50 and lasts for 50 minutes. There is no news but both Reuters and Bloomberg report that this is due to U.S.-opening covering of positions following heavy Bank of Japan intervention. At 15:40, another 35 minute switch occurs for which there is no public news. Finally, at 18:50, a 25 minute switch is associated with news of a strike at a General Motors plant.

October 4, 1994: There is only 1 state on this day of very low volatility.
November 22, 1994: A switch to state 2 occurs at 12:50 and lasts the rest of the day as Bundesbank President Tietmeyer gives a speech that continues generating Reuters headlines for over an hour. The speech includes comments on a strong mark being in Germany’s interest along with comments on M3 targets and appropriate interest rate policy. Later in the day, the U.S. stock market suffered its largest drop in 9 months and Bloomberg reports that the last hour of trading was a “ferocious selling frenzy.”

December 27, 1994: There is essentially 1 state on this day of very low volatility.

February 8, 1995: There is essentially 1 state on this day of low volatility.

April 4, 1995: State 2 exists at the morning start of sample following major BOJ intervention and lasts until 10:00. At 11:40 another switch to state 2 occurs with no apparent news. However, Reuters reports that “DLR opens higher in US on intervention uncertainty.” The BOJ had intervened earlier that day and that followed heavy U.S. intervention on the prior day. So there was an expectation in the market of further intervention. Then at 18:45 another switch to state 2 occurs with Kantor’s speech announcing no progress in talks with Japan to open the Japanese auto market. News reports stated that traders believed U.S. policy was aimed at talking down the dollar to pressure Japan in the trade talks.

II.E. A Comparison of FOMC and Control Days

In this section, a summary of the differences between the exchange rate dynamics on FOMC days and control days is provided. FOMC meetings always start at 14:00 GMT (13:00 DST). The ending time varies, but over the sample used in this study, the mean ending time was 18:49 for meetings during standard time and 18:11 for DST meetings. Seven of the nine FOMC days with two states (December 20, 1994 has essentially only 1 state) have a switch to the informed trading state during the meeting time. On one day, the switch occurs prior to the meeting start due to news (Feb. 4, 1994) and on another day, the switch occurs at meeting end (Feb. 1, 1995). Of the seven days with intrameeting time state switches, five
have no public news associated. If we count meeting time as the period 14:00 to 18:40 (13:00
to 18:11 DST), then three of the control days have switches to the informed trading state
during normal meeting time. Only one of these days has no public news associated with the
switch. So the evidence is consistent with FOMC days having a greater tendency for the
informed-trading state to emerge during the meeting time and emerge independent of public
news.

Control days tend to have less volatility. The average state 2 variance estimated for
FOMC days was 68.88. For control days, the average was 37.29. Only one FOMC day had
essentially 1 state, and this was the low volatility holiday period of December 20, 1994. The
corresponding control day, December 27, 1994 also had only 1 state, but so did two additional
control days that were outside of the holiday period. Such days are consistent with liquidity-
motivated trading so that the exchange rate moves randomly in a narrow band.

An alternative to the private information-based story told so far is that the switches
to state 2 could be related to liquidity and inventory control completely apart from any
information-based motives. Suppose that in the hours prior to the end of an FOMC meeting
market depth falls as traders are reluctant to take positions given the uncertainty of the
meeting outcome. In this case, we could observe more volatile exchange rates based only on
liquidity-motivated trades as dealers must be induced to take a position in a thin market.
Without actual trade data (which are proprietary information in FX trading), one must
exercise caution in discussing liquidity in this market. A few studies have obtained a
snapshot of a portion of the market from Reuters electronic trading via the direct-dealing or
electronic brokerage networks. A necessary limitation of such an analysis, is that only a
fraction of the actual market trade activity is recorded and only for a short period of time. A
particularly useful study is that of Danielsson and Payne (2002), who study the indicative
quotes from Reuters along with the electronic brokerage data for one week. Of note for the
present analysis is that the indicative quote frequency closely matches the aggregate
liquidity demand on the electronic brokerage. So one may have some confidence that quote
frequency is a reasonable proxy for intraday market depth. With this in mind, a comparison of quote frequency on FOMC days and control days is constructed. Table 3 contains the average number of quotes per minute during FOMC meeting times for meeting days and control days. The meeting times are as given in Table 1 using the Reuters announced ending times. The control days use the mean ending times of 18:49 GMT for standard-time meetings and 18:11 for DST meetings. Table 3 shows quite clearly that quote frequency during FOMC meetings gives no support to the hypothesis that low liquidity is behind the greater volatility during FOMC meetings. The average number of quotes during FOMC meetings is quite similar to that of control days—sometimes there is a bit higher quote frequency during the FOMC meeting than the control day and sometimes there is a bit less. So low liquidity and inventory-based trading seem unlikely to be the source of the exchange rate dynamics observed during FOMC meetings.

Taken as a whole, it seems fair to say that FOMC days are different from other days in terms of volatility dynamics and provide a useful laboratory for studying the issues under investigation here: namely private-information-motivated trading. Of course, to explore this issue in depth requires more than an analysis of the intradaily exchange rate change. We next turn to the evidence in intradaily spreads.
III. Bid-Ask Spreads and FOMC Days

If informed traders are taking positions based on expectations of FOMC policy changes, we should expect dealers' spreads to reflect the increased probability of quoting to an informed trader. During periods in the day when we expect the market to be relatively rich in informed trading, we would expect to see spreads reflect the potential for adverse selection. Of course, the spreads will also reflect inventory control along with the cost of providing dealer services.

In order to focus on the adverse selection component of the spread for FOMC days, we should consider the strategic trading of the informed. Microstructure theory provides some guidance in this area. Traders expect the FOMC to either raise the federal funds rate or do nothing. Consequently, they expect dollar appreciation to be associated with a policy change. Based upon this expectation, informed traders expecting FOMC action will seek to accumulate long dollar positions. In response, market-making dealers will tend to raise their ask price for dollars against marks and widen their spreads.

We examine the evidence related to quoted spreads on FOMC days to infer the extent to which quoting behavior suggests the presence of certain periods when the adverse selection component of the spread becomes more relevant. The data are as described in the prior section. Mark/dollar spreads are averaged over 5-minute intervals for each FOMC meeting in our sample period. Since the Reuters data employed in this study are indicative quotes displayed to the market at large, they will bracket the firm quotes made in bilateral trading. Since there are no historical data of firm quotes available at the frequency we

---

7 An important aspect of market making is that the bid-ask spread must provide profits from liquidity-motivated trades that will offset the losses from information-motivated trades. O'Hara (1995) provides a good overview.
require for our sample period, we utilize the indicative quotes and believe they are reflective of the general conditions in the market.8

III.A. An Empirical Spread Model

In order to study the intraday spread dynamics on FOMC days, we construct the following variable to measure quoted spread conditions. The variable Spread is defined to take on a limited number of values reflecting the discreteness in spreads. Rather than a continuous variable, quoted spreads tend to concentrate on a few "round" numbers.9 Specifically, we define Spread as follows:

\[
\begin{align*}
\text{spread} \leq 5 & \Rightarrow 0 \\
5 < \text{spread} < 10 & \Rightarrow 1 \\
\text{spread} = 10 & \Rightarrow 2 \\
\text{spread} > 10 & \Rightarrow 3
\end{align*}
\]

The coding of spreads in this manner motivates our use of an ordered probit analysis to explore the spread dynamics during FOMC meetings. The model is easily thought of as a latent regression, \( sp^* = \beta'x + \epsilon \), where a continuous latent variable \( sp^* \) is unobserved, but we do observe \( sp \). The observed category for \( sp \) is based on \( sp^* \) where \( sp = 0 \) if \( sp^* \leq 0 \), \( sp = 1 \) if \( 0 < sp^* \leq \mu_1 \), \( sp = 2 \) if \( \mu_1 < sp^* \leq \mu_2 \), and \( sp = 3 \) if \( \mu_2 < sp^* \). The ordered probit procedure estimates the unknown threshold parameters along with \( \beta \).

Our independent \( x \) variables are State, the state variable estimated in the previous section via the Markov-switching model, and \( \text{Spread}_{t-1} \), the lagged spread. We expect spreads to have persistence over time so the lagged spread is included as a guard against the

---

8 A few studies have used firm quotes from electronic broking systems to demonstrate that such quotes have narrower spreads. While we should expect firm quotes in bilateral dealing to be narrower than indicative quotes, a problem with comparing spreads from the electronic brokerage system with the direct dealing network is that the broker screen reveals the "inside" spread or the best bid and offer available across all quoting dealers at any point in time, while the indicative quotes are postings of individual dealers. In addition, we do not use the raw spreads in our empirical work but ordered categories capturing spreads from small to large.

9 Bollerslev and Melvin (1994) provide an extensive discussion of the discrete nature of quoted spreads.
state variable (which depends on past information) just proxying for the persistence in the spread. Our empirical estimates will indicate if State accounts for the spread movements based upon adverse-selection potential or whether there is an independent role for State beyond the effect of including the lagged spread. The model is estimated over the period from 8:00 GMT to 30 minutes following the meeting end each day.

Estimates of the ordered probit model are presented in Table 4. Results differ across FOMC meeting days, although all coefficients are positive as expected. State is seen to have a statistically significant positive effect on eight days. The positive signs for the State variable are consistent with informed traders having worthwhile information regarding dollar movements in state 2, the informed state, that leads dealers to protect against adverse selection by raising Spread.

The lagged spread has a statistically significant positive effect on six days. So while there is evidence of a significant impact of including the lagged term, State has an independent effect on the spread apart from capturing any persistence in the spread.

Ordered probit coefficients cannot be interpreted in the same manner as in the standard regression setting. To have a sense of the economic significance of the estimates requires a simulation methodology to explore the sensitivity of the results to shifts in the independent variables. To examine the economic effects of the state variable on spreads, it seems reasonable to evaluate the model at the two most interesting values of State, zero and one. We use the estimates reported in Table 4 to simulate the probabilities of spread falling into the four dependent variable categories with the model evaluated at State equal to zero and then repeat the exercise with State set equal to one. The resulting changes in the model-generated probabilities are listed in Table 5.

To understand the simulation outcome, we focus on the results reported for February 4, 1994. The simulation results are for a shift in the probability of being in state 2 from zero to one. The row for 4 Feb. 94 indicates that the probability of spread being less than or equal to 5 basis points decreases by about 9 percentage points, the probability of spread being
between 5 and 10 basis points decreases by almost 9 percentage points, the probability of spread equaling 10 basis points rises by almost 16 percentage points, and the probability of spread being greater than 10 basis points rises by about 2.5 percentage points. A review of the magnitudes of probability shifts across the table reveals shifts in spread probabilities that are surely economically significant.

With few exceptions, the simulated changes in probabilities reported in Table 5 suggest economically significant positive effects of State on Spread. Overall, the simulation results indicate that the model captures effects on the spread that are both economically as well as statistically significant. Generally, as the probability of informed traders being active rises, spreads widen in a manner consistent with dealers protecting against adverse selection.
V. SUMMARY

FOMC meeting days, when there may be a change in interest rates, provide a natural laboratory for studying exchange rate dynamics when there is an ongoing policy meeting that may change a fundamental determinant of exchange rates. We analyze the exchange rate evidence for ten FOMC meeting days following the change in FOMC policy in early 1994 where federal funds rate target changes are announced to the market at the meeting conclusion. Our analysis focuses on the time of day when informed position taking occurs and bid-ask spread behavior in the face of likely informed trader activity.

To estimate the time of informed trader position taking, we estimate a switching-regime model of microstructure-motivated exchange rate determination using five-minute observations on the mark/dollar exchange rate for each FOMC meeting day over the period from February 1994 to March 1995. Our prior belief was that FOMC days would be characterized by the exchange rate trading in a narrow range or low-volatility regime prior to the end of the meeting when a shift to a high-volatility regime would occur as the meeting outcome results in trading motivated by the news release. Only four meetings yield evidence of the meeting outcome being price-relevant news not fully anticipated by the market. On one no-action day, the exchange rate returns exhibit small random changes over the entire day consistent with only liquidity trading. On another no-action day, there were but three brief switches to the informed-trading regime prior to the meeting end. For the remainder of the meetings, there were switches to the informed-trading regime well before the meeting end. On these days, the switch to state 2 occurred any where from 20 minutes to 4 hours and 45 minutes prior to the meeting end with a mean switching time of about 3 hours prior to meeting end. A careful review of the news on each day suggests that these results cannot be explained as the response to public information shared equally by all. This is consistent with a market where informed traders are taking positions in advance of the meeting end based
upon their expectations of the outcome. A comparison with a control sample suggests that these results do not represent the everyday behavior of the market. FOMC days are special.

If dealers believe that informed traders are active, they will tend to widen spreads to protect against adverse selection in quoting. We examine the evidence of such behavior on FOMC days by analyzing an ordered probit model of spreads where spreads are modeled as being determined by the current state of the market as measured by the probability of being in state 2 (the informed trading state) and the lagged spread. The state variable is seen to have a statistically significant effect on quoted spreads. Simulation results indicate that State also has economically meaningful effects on the bid-ask spread in addition to the estimated statistical significance. The general finding is that the greater the probability of being in state 2, the informed-trading state, the greater the spread. This result is consistent with market-makers widening spreads to protect against adverse selection as the probability of quoting to an informed trader increases.

Overall, our evidence indicates that FOMC days provide a useful setting for examining important hypotheses regarding exchange rate determination in a microstructure setting. The market appears to generally anticipate meeting outcomes well before the conclusion of the meetings. In this sense, the realization of the meeting outcome is often not news. Public information arrival cannot explain all the shifts to the informed trading states before meetings end. Relating our estimates of the probability of being in the informed trading state to quoted spreads, spreads appear to widen as the probability of quoting to an informed trader increases. Taken as a whole, it appears that exchange rates on FOMC days provide evidence of a market with normal periods of liquidity-motivated trading associated with exchange rates trading in a narrow band with low volatility alternating with periods of informed trading activity where wide swings in exchange rates occur and volatility is significantly higher. A particularly interesting finding is that the informed-trading regime tends to emerge during the time that the FOMC meets.
REFERENCES


Table 1. FOMC Meeting Days, Times, and Action

<table>
<thead>
<tr>
<th>Date</th>
<th>Meeting time (GMT)**</th>
<th>Change in fed funds target</th>
<th>Expected*</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starts</td>
<td>Ends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Feb. 94</td>
<td>14:00</td>
<td>16:13</td>
<td>0.25%</td>
<td>0.25%</td>
</tr>
<tr>
<td>22 Mar. 94</td>
<td>14:00</td>
<td>19:29</td>
<td>0.25%</td>
<td>0.25%</td>
</tr>
<tr>
<td>17 May 94</td>
<td>13:00</td>
<td>18:34</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>6 July 94</td>
<td>13:00</td>
<td>18:26</td>
<td>0-0.25%</td>
<td>0.00%</td>
</tr>
<tr>
<td>16 Aug. 94</td>
<td>13:00</td>
<td>17:22</td>
<td>0-0.25%</td>
<td>0.50%</td>
</tr>
<tr>
<td>27 Sep. 94</td>
<td>13:00</td>
<td>18:24</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>15 Nov. 94</td>
<td>14:00</td>
<td>19:21</td>
<td>≥0.50%</td>
<td>0.75%</td>
</tr>
<tr>
<td>20 Dec. 94</td>
<td>14:00</td>
<td>19:19</td>
<td>0-0.50%</td>
<td>0.00%</td>
</tr>
<tr>
<td>1 Feb. 95</td>
<td>14:00</td>
<td>19:17</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
<tr>
<td>28 Mar. 95</td>
<td>14:00</td>
<td>19:15</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

* The expected change in the federal funds rate as reported in *The Wall Street Journal*

**Reuters reported time and (official ending time).
Table 2. Estimates of Markov-Switching Models for Trading Activity

The table reports estimates of a model of informed traders taking positions at time $t_0$ on FOMC days. We assume that there exists an unobserved state variable $s$ that takes on the value one or two when the observed change in the exchange rate is drawn from a $N(\mu_1, \sigma_1^2)$ distribution or a $N(\mu_2, \sigma_2^2)$ distribution, respectively. State 1 is the usual state of liquidity-motivated trades or $\Delta S_t = \epsilon_t$, where the exchange rate moves randomly with a relatively small variance. State 2 is the state containing the informed trades where the exchange rate change may be characterized by relatively large swings and variance is higher. We expect the general state of the market to be dominated by liquidity trading so that state 1 normally prevails and $p_{11}$, the probability of remaining in state 1 next period if in state 1 this period, should be larger than $p_{22}$, the probability of remaining in state 2 next period if in state 2 this period.

<table>
<thead>
<tr>
<th>DATE</th>
<th>$\mu_1$</th>
<th>$\mu_2$</th>
<th>$\sigma_1$</th>
<th>$\sigma_2$</th>
<th>$p_{11}$</th>
<th>$p_{22}$</th>
<th>Log L</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Feb. 94</td>
<td>-0.306</td>
<td>2.241</td>
<td>4.363</td>
<td>98.69</td>
<td>0.981</td>
<td>0.955</td>
<td>-290</td>
</tr>
<tr>
<td></td>
<td>(0.22)</td>
<td>(1.37)</td>
<td>(0.79)</td>
<td>(19.8)</td>
<td>(0.01)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>22 Mar 94</td>
<td>-0.005</td>
<td>-0.188</td>
<td>4.824</td>
<td>65.152</td>
<td>0.982</td>
<td>0.926</td>
<td>-256</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(1.33)</td>
<td>(0.69)</td>
<td>(17.0)</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>17 May 94</td>
<td>0.031</td>
<td>0.134</td>
<td>2.651</td>
<td>25.461</td>
<td>0.981</td>
<td>0.958</td>
<td>-228</td>
</tr>
<tr>
<td></td>
<td>(0.17)</td>
<td>(0.66)</td>
<td>(0.66)</td>
<td>(7.45)</td>
<td>(0.02)</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>6 Jul 94</td>
<td>0.134</td>
<td>-0.102</td>
<td>4.984</td>
<td>46.553</td>
<td>0.962</td>
<td>0.912</td>
<td>-273</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.93)</td>
<td>(1.12)</td>
<td>(11.4)</td>
<td>(0.02)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>16 Aug 94</td>
<td>-0.099</td>
<td>1.338</td>
<td>7.374</td>
<td>325.2</td>
<td>0.992</td>
<td>0.962</td>
<td>-303</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(3.17)</td>
<td>(0.96)</td>
<td>(81.7)</td>
<td>(0.01)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>27 Sep 94</td>
<td>-0.001</td>
<td>-1.542</td>
<td>3.134</td>
<td>41.88</td>
<td>0.980</td>
<td>0.934</td>
<td>-231</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(1.04)</td>
<td>(0.48)</td>
<td>(10.22)</td>
<td>(0.01)</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>15 Nov 94</td>
<td>0.117</td>
<td>1.208</td>
<td>2.872</td>
<td>43.65</td>
<td>0.991</td>
<td>0.977</td>
<td>-250</td>
</tr>
<tr>
<td></td>
<td>(0.18)</td>
<td>(0.85)</td>
<td>(0.44)</td>
<td>(8.11)</td>
<td>(0.01)</td>
<td>(0.02)</td>
<td></td>
</tr>
<tr>
<td>20 Dec 94</td>
<td>-0.416</td>
<td>-0.032</td>
<td>0.335</td>
<td>2.506</td>
<td>0.733</td>
<td>0.943</td>
<td>-134</td>
</tr>
<tr>
<td></td>
<td>(0.21)</td>
<td>(0.14)</td>
<td>(0.23)</td>
<td>(0.38)</td>
<td>(0.14)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>1 Feb 95</td>
<td>-0.070</td>
<td>-0.734</td>
<td>6.773</td>
<td>24.61</td>
<td>0.992</td>
<td>0.972</td>
<td>-246</td>
</tr>
<tr>
<td></td>
<td>(0.24)</td>
<td>(1.07)</td>
<td>(0.95)</td>
<td>(7.98)</td>
<td>(0.01)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>28 Mar 95</td>
<td>-0.145</td>
<td>-9.460</td>
<td>11.13</td>
<td>15.14</td>
<td>0.969</td>
<td>0.551</td>
<td>-284</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(2.20)</td>
<td>(1.51)</td>
<td>(9.70)</td>
<td>(0.02)</td>
<td>(0.18)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors are in parentheses.
Table 3. Quote Frequency on FOMC Days and Control Days

The table reports the average number of mark/dollar quotes per minute posted on the Reuters indicative quoting screen during FOMC meetings. Meeting times are as given in Table 1 using the Reuters announcement of the ending time. For each meeting day, a control day is selected as one week later on the same day of the week. Control day quote frequency is computed using the mean meeting-ending time of 18:49 GMT across all meetings held during standard time and 18:11 for the mean ending time of the four meetings held during daylight saving time (May through September).

<table>
<thead>
<tr>
<th>Meeting Day</th>
<th>Meeting</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Feb. 94</td>
<td>7.0</td>
<td>4.0</td>
</tr>
<tr>
<td>22 Mar. 94</td>
<td>4.3</td>
<td>4.0</td>
</tr>
<tr>
<td>17 May 94</td>
<td>3.9</td>
<td>4.5</td>
</tr>
<tr>
<td>6 July 94</td>
<td>4.0</td>
<td>4.7</td>
</tr>
<tr>
<td>16 Aug. 94</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td>27 Sep. 94</td>
<td>4.7</td>
<td>4.2</td>
</tr>
<tr>
<td>15 Nov. 94</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>20 Dec. 94</td>
<td>2.3</td>
<td>1.2</td>
</tr>
<tr>
<td>1 Feb. 95</td>
<td>3.6</td>
<td>4.6</td>
</tr>
<tr>
<td>28 Mar. 95</td>
<td>2.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>
The table reports estimates of an ordered probit model of intra-daily spreads on the mark-dollar exchange rate on FOMC days. The dependent variable $Spread$ takes on the following values:

- $\text{spread} \leq 5 \Rightarrow 0$
- $5 < \text{spread} < 10 \Rightarrow 1$
- $\text{spread} = 10 \Rightarrow 2$
- $\text{spread} > 10 \Rightarrow 3$

where spread equals 5-minute average (asks-bids) on the mark price of the dollar. Explanatory variables are $State$, the state variable estimates reported in Table 2; and $Spread_{t-1}$, the lagged spread (included to guard against $State$ simply capturing the persistence in the spread). Data are sampled at 5-minute intervals and run from 8:00GMT London time until 21:00GMT on each FOMC meeting day.

<table>
<thead>
<tr>
<th>Date</th>
<th>$State$</th>
<th>$Spread_{t-1}$</th>
<th>Log L</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Feb. 94</td>
<td>0.500</td>
<td>0.344</td>
<td>-155</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>22 Mar. 94</td>
<td>0.997</td>
<td>0.184</td>
<td>-147</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.19)</td>
<td></td>
</tr>
<tr>
<td>17 May 94</td>
<td>0.657</td>
<td>0.238</td>
<td>-141</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.10)</td>
<td></td>
</tr>
<tr>
<td>6 Jul. 94</td>
<td>0.455</td>
<td>0.329</td>
<td>-156</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>16 Aug. 94</td>
<td>0.855</td>
<td>0.479</td>
<td>-161</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>27 Sep. 94</td>
<td>0.362</td>
<td>-0.124</td>
<td>-135</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.43)</td>
<td></td>
</tr>
<tr>
<td>15 Nov. 94</td>
<td>0.409</td>
<td>0.272</td>
<td>-156</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>20 Dec. 94</td>
<td>-0.455</td>
<td>0.079</td>
<td>-154</td>
</tr>
<tr>
<td></td>
<td>(0.33)</td>
<td>(0.55)</td>
<td></td>
</tr>
<tr>
<td>1 Feb. 95</td>
<td>1.157</td>
<td>0.296</td>
<td>-145</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>28 Mar. 95</td>
<td>0.735</td>
<td>0.070</td>
<td>-160</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.58)</td>
<td></td>
</tr>
</tbody>
</table>

Note: p-values are in parentheses
Table 5. Sensitivity Analysis of Simulated Probabilities

The table reports the change in the probabilities of the spread falling into each of the different categories of the ordered probit model when the model is evaluated first with the explanatory variable State (the probability of being in the informed trading state) at a value of zero and then at a value of one. The categories are:

- $\mu_0$: spread $\leq 5 \Rightarrow 0$
- $\mu_1$: $5 < \text{spread} < 10 \Rightarrow 1$
- $\mu_2$: spread $= 10 \Rightarrow 2$
- $\mu_3$: spread $> 10 \Rightarrow 3$

For those days when the spread never exceeded 10 basis points, only three categories are reported.

<table>
<thead>
<tr>
<th>Date</th>
<th>$\mu_0$</th>
<th>$\mu_1$</th>
<th>$\mu_2$</th>
<th>$\mu_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Feb. 94</td>
<td>-0.0948</td>
<td>-0.0895</td>
<td>0.1595</td>
<td>0.0248</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Mar. 94</td>
<td>-0.2356</td>
<td>-0.0932</td>
<td>0.3288</td>
<td></td>
</tr>
<tr>
<td>17 May 94</td>
<td>-0.2503</td>
<td>0.1221</td>
<td>0.1281</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 July 94</td>
<td>-0.1436</td>
<td>0.0047</td>
<td>0.1389</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Aug. 94</td>
<td>-0.1690</td>
<td>-0.1398</td>
<td>0.2453</td>
<td>0.0635</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Sep. 94</td>
<td>-0.1387</td>
<td>0.0872</td>
<td>0.0515</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Nov. 94</td>
<td>-0.1513</td>
<td>0.0418</td>
<td>0.1095</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Dec. 94</td>
<td>0.1785</td>
<td>-0.0919</td>
<td>-0.0866</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Feb. 95</td>
<td>-0.3461</td>
<td>0.0319</td>
<td>0.2839</td>
<td>0.0304</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 Mar. 95</td>
<td>-0.2056</td>
<td>-0.0527</td>
<td>0.2583</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1a: FOMC meeting day February 4, 1994

Figure 1b: FOMC meeting day March 22, 1994
Figure 1c: FOMC meeting day May 17, 1994

Figure 1d: FOMC meeting day July 6, 1994
Figure 1e: FOMC meeting day August 16, 1994

Figure 1f: FOMC meeting day September 27, 1994
Figure 1i: FOMC meeting day February 1, 1995

Figure 1j: FOMC meeting day March 28, 1995