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Monetary Policy, the Bond Market, and Changes in FOMC Communication Policy

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Abstract

Using high-frequency data in a Markov-switching framework, we identify states that imply different responses of the yield curve to unexpected changes in the federal funds target. Empirical estimates reveal a low-volatility state where long-term bonds respond significantly, and in a predictable manner, to unexpected changes in the federal funds target. An alternative state exists with higher volatility, where unexpected changes in the federal funds target raise the short-end of the yield curve, but have no significant effect on the long-end. The low-volatility state for long-term bonds occurs from September 1995 to May 1999 and again from March 2000 to January 2002. The timing of the switches between the two states for long-term bonds coincides with changes in FOMC communication policy – though not all changes in communications policy induce a switch.

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1. Introduction

An important tool at the disposal of modern central banks is their method of how they communicate with the public.[1] Bond market volatility and the response of the yield curve to monetary policy reflects the effectiveness of a communication strategy. For example, Blinder et. al. (2001) anecdotally note that the Federal Reserve's success in communicating its policy strategy resulted in a period from 1996-1999 when the bond market was 'doing the Fed's work for it.' In other words, the bond market entered a state when Fed policy objectives and statements were better understood, resulting in bond yields adjusting in a more predictable manner to monetary policy and developments in the economy.[2] For example, long-rates would often rise when inflation or growth was unexpectedly high and fall in the presence of more benign macroeconomic data, allowing the Fed to leave the federal funds target nearly unchanged during this period. A bond market that understands the objectives and communications from a central bank should quickly internalize what unexpected changes to the monetary policy instrument implies for bond prices. In other words, bond markets should exhibit less volatility in periods when this clear understanding exists.

To isolate the effect of how unexpected changes in the federal funds target impact bond prices, this paper uses high-frequency data in a Markov-switching framework. Such a framework permits the volatility and response of bond prices to vary over time. To measure the response of bond prices and yields of different maturities to unexpected changes in the federal funds target, we use the change in the 3-month Eurodollar futures, 5-year Treasury note futures, and 30-year Treasury bond futures in the 30-minute window around Federal Open Market Committee (FOMC) announcements. The estimation procedure endogenously delineates the sample into different states, finding both the conditional responses and volatilities of the different assets vary across states and time. A low-volatility state exists, where the bond market adjusts yields in the same direction as unexpected changes in the federal funds target. The timing of this state for longer term bonds corresponds to the period mentioned above by Blinder et. al. (2001), when the bond market had a clear interpretation of monetary policy and thus, responded in a predictable manner. Predictable yield curve movements then assist the Fed in achieving its objectives, since long-term rates play an important role in consumption and investment decisions.

Specifically, the low-volatility state exists for longer term bonds from roughly mid-1995 to mid-1999, where an unexpected increase in the federal fund target induces a statistically significant effect on assets of all maturities and bond prices exhibit a low degree of volatility. In this low-volatility state, an unexpected change in the federal

[1]See Woodford (2005) and Blinder, Goodhart, Hildebrand, Lipton, and Wyplosz (2001) for comprehensive overviews.

[2]Blinder, Goodhart, Hildebrand, Lipton, and Wyplosz (2001) refer to the bond market and Fed entering a state of 'symbiosis.'

funds target leads to a shift in the yield curve and implies the Federal Reserve is capable of influencing long-term interest rates. For 30-year futures, the low-volatility state ends in May 1999, the meeting when the FOMC began stating a policy 'bias' to guide policy expectations for the next meeting. In the high-volatility state, which is in place the remaining periods of the sample, unexpected changes to the federal funds target have statistically significant effects on the price of 3-month and 5-year futures, but do not affect the price of the 30-year bond future. This state exhibits higher volatility and implies Fed actions are not effective at influencing the long-end of the yield curve.

2. Related Literature

Recent empirical work on the relationship between monetary policy and long-term rates, including papers by Cook and Hahn (1989), Kuttner (2001), Cochrane (2002), Faust, Rogers, Wange, and Wright (2005), Rigobon and Sack (2004), and Gurkaynak, Sack, and Swanson (2005), supports the view that monetary policy can affect long rates. This work typically finds that changes in the federal funds target were followed by large movements in the same direction in short-term interest rates, moderate movements in intermediate-term rates, and small, but significant movements in long-term rates.

Other research, though, presents evidence that is inconsistent with that pattern. Poole, Rasche, and Thornton (2002), Berument and Froyen (2004), and Demiralp and Jordà (2004), for example, show that the positive relationship between monetary policy shocks and long-term interest rates weakens over time and is not significant in recent periods. Gurkaynak, Sack, and Swanson (2005) show that at long horizons forward interest rates move in the opposite direction of policy shocks, a finding consistent with the view that short term movements in the federal funds target move inflation expectations in the other direction. However, this negative relationship between policy shocks and forward rates also seems to weaken in more recent U.S. data. For example, Gurkaynak, Levin, and Swanson (2006) find that long-term forward rates do not respond significantly to monetary policy in the 1999-2005 period.

Empirical evidence also exists suggesting the effect of monetary policy shocks on long-term interest rates varies depending on the business cycle and the type of policy move. Andersen, Bollerslev, Diebold, and Vega (2005) find that federal funds surprises are positively related to long-term interest rates from 1992-2002. However, the effect is strong and significant during the expansion period (1992-2001), but insignificant during the recession period (2001-2002). Ellingsen, Söderström, and Massenz (2004) find that the response of long-term interest rates to monetary policy shocks is positive when those shocks are endogenous, which they define as policy moves in which the Fed is responding to economic developments. When the shocks are exogenous, defined as policy moves in which the Fed changes its policy preferences, the response of long rates is negative.

Some recent research suggests that understanding how markets interpret central bank actions is crucial for understanding the effect of monetary policy on long-term interest rates. For example, Amato, Morris, and Shin (2002), Ellingsen and Söderström (2004), and Beechey (2004) model how movements in long-term rates depend on how market participants interpret policy shocks.

3. Data

The sample consists of the 84 announcements associated with FOMC meetings from 1994, when the Federal Reserve began to announce its policy decisions, through 2003.[3] Following Kuttner (2001), we use daily 30-day federal funds rate futures, available from the Chicago Board of Trade, to measure the unexpected component of Federal Reserve policy decisions. The advantage of using high frequency data is to isolate the effects surprise FOMC announcements have on different points of the (futures) yield curve. Tickdata provided the interest rate data, which include Eurodollar futures that are traded on the Chicago Mercantile Exchange, and 5-Year U.S. Treasury Notes futures and 30-Year U.S. Treasury Bonds futures that are traded on the Chicago Board of Trade. We calculate the returns on the futures as the log difference of the closing prices of the front contracts at the beginning and the end of a 30-minute window around announcements following regularly scheduled FOMC meetings and inter-meeting rate changes.[4] As Andersen, Bollerslev, Diebold, and Vega (2005) note, futures markets have lower transaction costs, active trading, and tend to lead cash markets in terms of price discovery. Thus, the futures data are appropriate for measuring returns on the three assets in a narrow window around FOMC announcements.

4. State-Dependent Bond Price Responses

The econometric strategy follows the approach in Davig and Gerlach (2006), which employs an event-study framework with a modification allowing the response of bond futures to vary according to a Markov-switching process. The framework permits variation in the response of bond futures to unexpected changes in the federal funds

[3]Following Bernanke and Kuttner (2005) and Gurkaynak, Sack, and Swanson (2005), we omit the move on 9/17/2001 following September 11, 2001 due to the extreme idiosyncratic nature of the policy move.

[4]The front contract rolls to the first back-month contract when the daily trading volume of the back-month contract exceeds the daily volume of the current front contract.

target in different states, but does not impose upon the model that the responses necessarily must differ. The model describing the response of futures is given by

$$P_t^M = a + b^u(S_t)\Delta i_t^u + \varepsilon_t, \tag{1}$$

where P_t^M is the return on a bond futures of maturity M, S_t is the unobserved state variable, Δi_t^u is the unexpected change in the federal funds target, and $\varepsilon_t \sim N(0, \sigma(S_t)^2)$. The variance of the error term also varies with the state, but requires synchronous switching of $b^u(S_t)$ and $\sigma(S_t)$.

The two-state Markov chain governing the evolution of the unobserved state is given by

$$\Pi = \begin{bmatrix} p_{00} & 1 - p_{00} \\ 1 - p_{11} & p_{11} \end{bmatrix}, \tag{2}$$

where $p_{ij} = \Pr[S_t = j | S_{t-1} = i]$ for $i = 0, 1$ and $j = 0, 1$. The likelihood function derives from a nonlinear iterative filter that formulates a probabilistic estimate of the state for each observation, see Hamilton (1989) and Kim and Nelson (1999) for details.

5. Empirical Estimates

Table 1 reports parameter estimates for the Markov-switching model for 3-month Eurodollar futures, 5-year Treasury note futures and 30-year Treasury bond futures. Parameter estimates are given for two samples, one including intermeeting moves and the other without.[5] Figure 1 shows the filtered and smoothed probabilities for each asset for the sample including intermeeting moves. The filtered probability of being in state j at t is $\Pr[S_t = j | \Omega_t]$, where Ω_t is the information set including all variables dated t or earlier. The smoothed probability is $\Pr[S_t = j | \Omega_T]$, where Ω_T includes information over the entire sample. Excluding intermeeting moves does not qualitatively alter the timing of the states for 3-month or 5-year futures, but has important implications for measuring the response of each asset to unexpected changes to the federal funds target, explained further below.

5.1. **3-month Eurodollar futures.** The top panel in Figure 1 shows frequent shifts between the two states for the 3-month Eurodollar futures and Figure 2 gives the corresponding scatter plots conditioning on each state. For descriptive purposes, we will refer to the states for each asset as either the 'high' or 'low' volatility states. Each state for the 3-month futures displays a negative relationship between unexpected changes in the federal funds target and price, although the magnitude of the response

[5] Intermeeting moves are those occuring at times other than pre-announced, scheduled FOMC meetings.

in the high-volatility state is larger than in the low-volatility state.[6] The response coefficients are significant at the 1% level in both states for each sample, indicating the unexpected component of changes to the federal funds target are quite effective at influencing the short-end of the yield curve.

The frequent switching for the 3-month futures could be viewed as evidence *against* the model incorporating switching. The rationale being that the switching does not have an underlying cause and instead, is simply absorbing noise in the series. In this case, a null hypothesis of no switching (i.e. simple OLS) should not be rejected against an alternative switching model. The next section formally tests this hypothesis and finds that OLS is rejected in favor of the switching model. Further, it is worth noting that the overall level of volatility in for the 3-month futures is relatively low when compared to the 5-year and 30-year futures, see Table 1 and Figure 2.

5.2. **5-year Treasury futures.** The middle panel in Figure 1 shows a clear shift in the state for 5-year Treasury note futures occuring from September 1995 to October 1998. During this period, prices for 5-year futures respond significantly at the 1% level to unexpected changes in the federal funds target and exhibit much lower volatility when compared to other dates in the sample. The middle row of Figure 2 gives the scatter plots conditional on each state, where the low-volatility state highlights a negative relationship between surprise changes and the price of the 5-year futures. In contrast to 3-month futures, the response to unexpected target rate changes is about twice as large in the low-volatility state relative to the high-volatility state for each sample. However, excluding intermeeting moves results in an insignificant response of the price to the unexpected component in the high-volatility state, indicating the large unexpected component arising from intermeeting changes to the federal funds target have an important influence on the response coefficient estimates.

5.3. **30-year Treasury futures.** For the 30-year Treasury bond futures, the bottom panel in Figure 1 indicates a shift from September 1995 to May 1999, roughly the same period as the 5-year futures. Scatter plots are given in the bottom row of Figure 2, clearly highlighting the change in volatility across states. The response of the 30-year futures price to unexpected changes in the low-volatility state using the sample including intermeeting moves is significant at the 1% level and stronger than for the 5-year futures. Excluding intermeeting moves weakens the response of the 30-year futures price to changes in the unexpected component, though the response remains significant at the 10% level. Also, the timing of the states changes, where a

[6]In Section 6, we report regression coefficients in which the dependent variable is an estimate, based on the futures price, of the yield for each of the three bonds. Those calculations likely introduce some errors into the estimates of the yield so our initial focus is on the returns to the futures. As noted above, the futures contracts are heavily traded and thus provide a highly reliable measure of the market response to FOMC announcements.

recurrence of the low-volatility occurs from 2000 to 2001. A further discussion of this second low-volatility state is given below, when the results are reinterpreted in terms of yield data. The failure to return to the low-volatility state, when using the sample including intermeeting moves, is due to the intermeeting moves that occur in January and April of 2001. The additional volatility induced by these meetings preclude the estimation procedure from picking up the low-volatility state that is found when using data from pre-scheduled FOMC meetings.

6. Specification Testing

An important specification test assesses whether a standard OLS specification can be rejected in favor of the Markov-switching model given in (1). Such a test suffers from the problem of nuisance parameters not being identified under the null hypothesis, as in Davies (1977), so standard asymptotic critical values are not applicable. The null hypothesis of interest is

$$H_0: \ b^u(0) = b^u(1) \text{ and } \sigma(0) = \sigma(1),$$

where the nature of the testing problem is clear - if the null holds, then p_{00} and p_{11} play no role and thus, are not identified. To appropriately perform the test, we use the method in Hansen (1992) based on empirical process theory to generate bounds on the asymptotic distribution of a standardized likelihood ratio test.[7] Table 2 provides p-values from the Hansen test for each asset for samples both including and excluding intermeeting moves. For 3-month, 5-year and 30-year futures, the p-values for the above null hypothesis for the sample including intermeeting moves are .002, .002 and .01, respectively, indicating the OLS specification can be rejected in favor of the Markov-switching alternative for each asset at conventional significance levels.[8]The OLS specification is also rejected for each asset for the samples excluding intermeeting moves at conventional significance levels.

The possibility does exist, however, that switching may be driven primarily by either the response coefficient or the volatility. To assess if one factor is relatively more important than the other, Table 2 also reports p-values from standard likelihood ratio tests imposing an equality restriction across states on either the response coefficient or variance. For $H_0 : \sigma(0) = \sigma(1)$, the p-values indicate the hypothesis can be rejected for each asset using either sample at conventional levels.[9] The results for the hypothesis testing constant response coefficients across regimes, $H_0 : b^u(0) = b^u(1)$, depends on

[7]We use a bandwidth of 4 in the Bartlett kernel used in simulating the covariance function, see Hansen (1996).

[8]Note that the values in Table 2 for the Hansen test are p-values based on bounds from simulating the asymptotic distribution. Hansen (1992) shows the bounds are conservative estimates, strengthening the conclusion that OLS can be rejected in favor of the Markov-switching alternative.

[9]Note that these tests do not suffer from the problem in Davies (1977), so we use standard distributional assumptions when computing the p-values in Table 2.

whether intermeeting moves are included in the sample. Constant responses, when including intermeeting moves, is rejected for both 3-month and 30-year futures. For 5-year futures including intermeeting moves, the hypothesis of equality of response coefficients across states can be rejected at the 10% level, but not the 5% level. When excluding intermeeting moves, constant responses across regime cannot be rejected at conventional significance levels for any of the assets, suggesting that volatility is a key factor in describing the switching for each asset.

7. Estimated Yield Responses

This section measures the response of estimated yields, instead of bond prices, to unexpected changes in the federal funds target. The advantage of using yield responses as the dependent variable is that estimates are more readily interpretable and comparable to previous studies.

7.1. **Empirical Estimates.**

The specification relates unexpected changes in the federal funds target to changes in the yield for each asset according to

$$R_t^M = a + b^u(S_t)\Delta i_t^u + \varepsilon_t, \tag{3}$$

where R_t^M represents the change in the yield over the 30-minute window around FOMC announcements for bond futures of maturity M and $\varepsilon_t \sim N(0, \sigma(S_t)^2)$. For the Eurodollar futures, we use the change in the forward rate implied by the futures prices in the 30-minute window around FOMC meetings. For the futures on the 5-year notes and 30-year bonds, we estimate the change in yield in the 30-minute window around FOMC meetings. Estimates are given in Table 3 and closely mirror those in Table 1. The response coefficient, b^u, can be interpreted as the yield response expressed in basis points to a 1% surprise change in the federal funds target. For example, using estimates from the sample including intermeeting moves, the 3-month rate rises approximately 75 basis points in the high-volatility state in response to a 1% surprise increase in the federal funds target.

The coefficient estimates are comparable to previous work. For example, Kuttner (2001) reports similar estimates using OLS for a sample from June 6, 1989 to February 2, 2000. For the 3-month rate, Kuttner (2001) reports a 62.8 bp (79.1 bp) response to a surprise 1% increase for the sample excluding (including) intermeeting moves. Using the sample including intermeeting moves, estimates from the Markov-switching model indicate a 35 bp response in the low-volatility state and a 75 bp response in the high-volatility state. Responses when excluding intermeeting moves are 36 and 90 bp in the low- and high-volatility states, respectively. Estimates of the response of the 3-month yield in both states for each sample are statistically significant and imply, similar to Kuttner (2001), that the Fed is capable of influencing the short end of the yield curve. However, the influence is strongest during the high-volatility state, which includes the majority of the sample.

For the 5-year rate, Kuttner (2001) reports a significant 36.3 bp (48.1 bp) response to a 1% surprise target increase for the sample excluding (including) intermeeting moves. The Markov-switching estimates are 34 bp in the low-volatility state and 17 in the high-volatility state, both significant at the 5% level. However, excluding intermeeting moves alters the estimates to 33 bp, significant at the 5% level, and an insignificant 12 bp in the low- and high-volatility states, respectively. These results suggest that the Fed is capable of influencing yields in the middle of the yield curve, but that the influence varies over time.

Kuttner (2001) reports surprise changes to the federal funds target have an insignificant effect on the 30-year futures rate. In the low-volatility state, the 30-year rate increases significantly by 15 bp in response to a 1% surprise increase in the federal funds target. Excluding intermeeting moves, the 30-year rate still responds significantly, but by less than when the sample includes intermeeting moves. In the high-volatility state for both samples, surprise changes have an insignificant effect. In addition, the volatility is roughly 10 times that of the low-volatility state.

The timing of when the different states occur using yield data is roughly the same as when using price data. Using the sample of changes occuring only on scheduled FOMC meetings, Figure 3 shows the low-volatility state is in place from September 1995 to May 1999 and again from March 2000 to January 2002 for the 30-year futures. The timing of the switching coincides to some changes in FOMC communication policy, as is discussed further below.

7.2. **OLS Comparison.** To assess how well changes in bond yields are captured by variations in the surprise component of the federal funds target, Tables 3 and 4 report OLS estimates for the samples corresponding to the low- and high-volatility states. The rule for separating the original sample is based on the smoothed probabilities, where a particular observation is sorted into the low volatility state if the smoothed probability of being in that state exceeds .5. Table 4 reports OLS estimates for observations including intermeeting moves from both states. Table 5 reports the same set of estimates, except excluding intermeeting moves. As expected, the results are consistent with those from the Markov-switching model, but of interest is the corresponding R^2 for each regression. Including intermeeting moves, the R^2s for the 3-month rate are .80 and .72 for the low- and high-volatility states, respectively. Excluding intermeeting moves drops the R^2s to .62 and .50, comparable to the value in Kuttner (2001) of .56.

A striking aspect of the OLS results is the drop in the R^2s for the 5-year futures between the low- and high-volatility state. In the low-volatility state, the R^2s are

.60 and .62 for the samples including and excluding intermeeting moves, respectively. These values drop to .05 and .02 in the high-volatility state. For the 30-year rate, the R^2 in the low-volatility state including intermeeting moves is .44, dropping to .06 when excluding intermeeting moves.

For the 5-year and 30-year yields, the R^2s are quite low in the high-volatility state for each sample. These result further suggest that the Fed is capable of influencing the entire yield curve with surprise changes to the federal funds target, but this ability varies over time and is effective in the low-volatility state.

8. Timing of FOMC Communication Policy Changes

Figure 3 shows changes in FOMC communication policy that Poole and Rasche (2003) identify and illustrates how those changes coincide with changes between the low- and high-volatility states. The shifts to the high-volatility state occur in early 1994, when the Fed began making public announcements concerning the federal funds target, and in May 1999, when the public statement began to include the statement of bias. In January 2000, the policy statement was further modified to include a 'balance of risk' statement, intended to provide guidance to the markets regarding expected future changes to the federal funds target. This change in communication policy actually coincides with a return to the low-volatility regime. There are two potential explanations: either this change in policy was immediately understood and alleviated the more volatile bond responses that began at the onset of the last communication policy change or was viewed by the bond market as a clarifying refinement to the change occurring in May 1999.

The onset of the high-volatility state again in January 2002 coincides with the change in communication policy in March of 2002, where voting outcomes and the names of any dissenting members were included in the press statement. Although revealing the voting outcomes signals the degree of unanimity on the FOMC and constitutes important information for markets, the timing of this state also likely reflects a general uncertainty associated with the future path of monetary policy. This state occurs after the 2001 recession, when the federal funds target was already low by historical standards. Typically, the federal funds target is gradually increased during a recovery from a recession and given the already low level of the federal funds target, one could reasonably expect an increasing path for the federal funds target during this period. However, general price inflation during the recovery phase was falling, generating concerns that the U.S. could be caught in a liquidity trap reminiscent of Japan in the 1990s. The concern with deflation, and possibly disinflation, suggested possible future easing of monetary policy. These countervailing effects could suggest the existence of relatively more uncertainty regarding the future path of monetary policy near the end of the sample.

The shifts to the high-volatility state do not suggest that increasing transparency in central bank communication policy is undesirable, but that it requires time from market participants to understand what the changes imply regarding the future path of policy. A return to the low-volatility state seemingly occurs once bond markets internalize how the new communication policy influences the bond price discovery process. However, an alternative interpretation of the low-volatility state is that it occurs in a period when there were only two moves in the federal funds target. This interpretation then views the absence of movement on the short-end of the yield curve as being reflected in the long-end. However, this view does not recognize that we are measuring the change in yields arising from unexpected changes in the federal funds target. A 'non-move' can still generate an unexpected move in the federal funds target. During the low-volatility state for the 30-year future, the average of the absolute value of surprises, excluding intermeeting moves, was 3.7 basis points. In the high-volatility state, the same measure is 4.1 basis points, suggesting that the absence of changes to the federal funds target is not the direct cause of the different volatilities across states.

9. Robustness Checks

Bond markets are sensitive not only to unexpected changes in the federal funds rate, but also to changes in its expected path. Other aspects of monetary policy such as policy reversals, discounted rate changes and the sign of the change to the federal funds target are potential factors affecting bond prices, since they may convey information that guide expectations regarding future policy.

Policy reversals refer to policy interventions resulting in a change in the federal funds target that moves it in the opposite direction relative to the most recent change. Such reversals may contain information to market participants regarding the Fed's economic outlook and whether a new tightening or easing policy cycle has begun. For example, Demiralp and Jordà (2004) provide evidence that policy reversals have a significantly positive impact on long-term rates. Likewise, discount rate changes and the direction of the change in the federal funds target may also contain relevant information for expectation formation and the pricing of bonds. Also, McQueen and Roley (1993), Andersen, Bollerslev, Diebold, and Vega (2005), and Boyd and Jagannathan (2005) indicate that the response of asset markets to new information may be sensitive to the state of the business cycle. To capture the impact of such effects, we use the following model

$$P_t^M = a + b^u(S_t)\Delta i_t^u + b^d d_t + \varepsilon_t, \tag{4}$$

where d_t denotes a dummy variable, and noting the coefficient, b^d, is not state-dependent.

Policy reversal, where $d_t = 1$ for the 6 times policy reversed course and 0 otherwise for the sample including intermeeting moves. Estimates indicate policy reversals are have a significant effect on 3-month futures, but otherwise contain no information for pricing bond futures of longer maturities. To control for asymmetry, $d_t = 1$ for the 15 times the change to the federal funds target was positive and 0 otherwise for the sample including intermeeting moves. As Table 6 reports, the dummy variable controlling for asymmetry is insignificant for all assets. Discounted rate changes, where $d_t = 1$ for the 23 times the discount rate was changed in conjuction with the federal funds target and 0 otherwise, may have some influence on the shorter end of the yield curve. Although, the magnitude of the effect of discount rate changes is extremely small. To control for the recession in the sample, $d_t = 1$ for the 7 times the FOMC met during NBER's dating of the 2001 recession, running from March 2001 to November 2001. For each asset, control for the recession does not have implications for bond pricing.

10. Conclusion

Previous research on the relationship between monetary policy shocks and long-term interest rates has come to various conclusions, depending on the data, time periods, and estimation techniques. If changes to FOMC methods of communication accompany policy shocks, and if methods of communication constitute important information regarding the future path of policy, ambiguous results should be expected using methods that do not permit time-variation in the response of interest rates to policy shocks.

Using high-frequency data, we find prices for bond futures of various maturities respond to monetary policy differently across time. A two-state Markov switching model indicates that two distinct states exist for each asset when measuring its response to surprise changes in the federal funds rate target - a 'low' and 'high' volatility state. In the low-volatility state, monetary policy can influence the yield curve, where the response of futures prices exhibit relatively low volatility and unexpected changes in the federal funds target can move the long-end of the yield curve. Estimates indicate the low-volatility state for long-term bonds was in place from September 1995 to May 1999 and from March 2000 to December 2001. Switches to the high-volatility state coincide with changes in FOMC communication policy - though, not all changes in communication policy coincide with these switches. In the high-volatility state, the response of futures prices are less predictable and monetary policy is effective primarily on at the short-end of the yield curve.

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	Including Intermeeting Moves			No Intermeeting Moves		
Parameter	3-month	5-year	30-year	3-month	5-year	30-year
a	.002	$-.015$	$-.042^{*}$	.002	$-.015$	$-.036$
	(.56)	(-1.12)	(-1.79)	(.51)	(-1.06)	(-1.56)
$b^u(0)$	$-.37^{**}$	-1.39^{**}	-1.86^{**}	$-.37^{**}$	-1.38^{**}	$-.68^{*}$
	(-8.25)	(-6.51)	(-5.41)	(-6.60)	(-6.66)	(-1.76)
$b^u(1)$	$-.78^{**}$	$-.72^{**}$	.67	$-.92^{**}$	$-.54$	.80
	(-8.68)	(-2.24)	(1.00)	(-2.54)	$(-.87)$	(.66)
$\sigma(0)^2$	$.0002^{**}$	$.0029^{**}$	$.013^{**}$	$.0003^{**}$	$.0028^{**}$	$.017^{**}$
	(2.58)	(2.64)	(2.82)	(2.74)	(2.93)	(3.25)
$\sigma(1)^2$	$.002^{**}$	$.063^{**}$	$.133^{**}$	$.003^{**}$	$.06^{**}$	$.17^{**}$
	(5.31)	(3.99)	(5.35)	(4.61)	(4.12)	(3.54)
ln Likelihood	167.49	28.19	-7.14	161.72	35.70	-4.25

TABLE 1. Maximum likelihood estimates of Markov-switching model measuring asset price responses to unexpected changes in the federal funds target. Parenthesis contain t-statistics. * and ** denote significance at the 10% and 5% levels, respectively.

H_0 :	Likelihood Ratio Test $b^u(0) = b^u(1)$	Likelihood Ratio Test $\sigma(0) = \sigma(1)$	Hansen Test $b^u(0) = b^u(1)$ and $\sigma(0) = \sigma(1)$
Including Intermeeting Moves			
3-month	.005	1.25e-6	.002
5-year	.096	4.71e-8	.002
30-year	.001	1.86e-7	.01
Excluding Intermeeting Moves			
3-month	.36	8.3e-6	.012
5-year	.139	3.46e-10	.001
30-year	.185	2.73e-7	.005

Table 2. Specification Tests : Values denote p-values.

	Including Intermeeting Moves			No Intermeeting Moves		
Parameter	3-month	5-year	30-year	3-month	5-year	30-year
a	$-.001$	.0037	.0034*	$-.001$	.0035	.0028
	$(-.49)$	(1.11)	(1.86)	$(-.51)$	(1.05)	(1.58)
$b^u(0)$	35.19**	33.76**	14.67**	36.13**	33.44**	5.50*
	(8.00)	(6.41)	(4.96)	(7.19)	(6.56)	(1.79)
$b^u(1)$	75.06**	16.87**	-5.18	89.79**	12.45	-7.97
	(8.61)	(2.21)	(-1.03)	(2.43)	(.85)	$(-.85)$
$\sigma(0)^2$	.0002**	.00017**	$8.4e-5$**	.0003**	.0002**	.0001**
	(2.61)	(2.52)	(2.53)	(2.93)	(2.78)	(3.01)
$\sigma(1)^2$	.0022**	.0035**	.0008**	.0025**	.0033**	.001**
	(5.02)	(4.04)	(5.44)	(4.23)	(4.18)	(3.34)
ln Likelihood	171.51	148.55	206.88	165.64	150.32	200.56

Table 3. Maximum likelihood estimates of Markov-switching model measuring term yield responses to unexpected changes in the federal funds target. Parenthesis contain t-statistics. * and ** denote significance at the 10% and 5% levels, respectively.

	Including Intermeeting Moves					
	3-month		5-year		30-year	
Parameter	[low σ]	[high σ]	[low σ]	[high σ]	[low σ]	[high σ]
a	$-.0008$	$-.011$	.0042	$-.0039$	.0037**	.001
	$(-.42)$	(-1.25)	(1.48)	$(-.49)$	(2.04)	(.25)
β^u	34.40**	76.18**	33.96**	15.90**	14.57**	-5.31
	(13.86)	(8.67)	(6.03)	(2.06)	(4.72)	(-1.39)
R^2	.79	.71	.60	.07	.44	.04
SE	.0002	.0026	.0002	.0036	$8.6e-5$	$8.3e-4$
DW	2.19	2.51	2.05	2.23	1.32	2.26
N	52	32	25	59	30	54

TABLE 4. OLS estimates measuring term yield responses to unexpected changes in the federal funds target by state. Parenthesis contain t-statistics. * and ** denote significance at the 10% and 5% levels, respectively.

	Excluding Intermeeting Moves					
	3-month		5-year		30-year	
Parameter	[low σ]	[high σ]	[low σ]	[high σ]	[low σ]	[high σ]
a	.0007	$-.021$	.0046*	$-.005$	.003*	$-.0014$
	(.27)	(-1.52)	(1.79)	($-.57$)	(1.83)	($-.24$)
β^u	42.32**	99.65**	34.45**	13.07	5.34	-6.98
	(9.88)	(3.99)	(6.52)	(1.07)	(1.60)	($-.91$)
R^2	.62	.50	.62	.02	.06	.02
SE	.0004	.0034	$1.6e-4$	.0034	$1.09e-4$	.0011
DW	2.20	1.88	2.05	2.19	1.9	2.07
N	61	18	28	52	44	36

Table 5. OLS estimates measuring term yield responses to unexpected changes in the federal funds target by state. Parenthesis contain t-statistics. * and ** denote significance at the 10% and 5% levels, respectively.

Future Price of :	Asymmetry	Discount Rate Changes	Policy Reversals	Recession
3-month Eurodollar	.008	$-.012^*$	$-.03$	$-.021$
	(.97)	(-1.95)	(-2.04)	(-1.50)
5-year Treasury note	.009	$-.018^*$	$-.004$	$-.019$
	(.53)	(-1.65)	$(-.30)$	(-1.41)
30-year Treasury Bond	.008	$-.008$	$-.016^*$	$-.002$
	(1.10)	(-1.20)	(-1.85)	$(-.06)$

Table 6. Robustness Checks. Values are the coefficient estimates on the dummy variable. Samples include intermeeting moves and parenthesis contain t-statistics, where * and ** denote significance at the 10% and 5% levels, respectively.

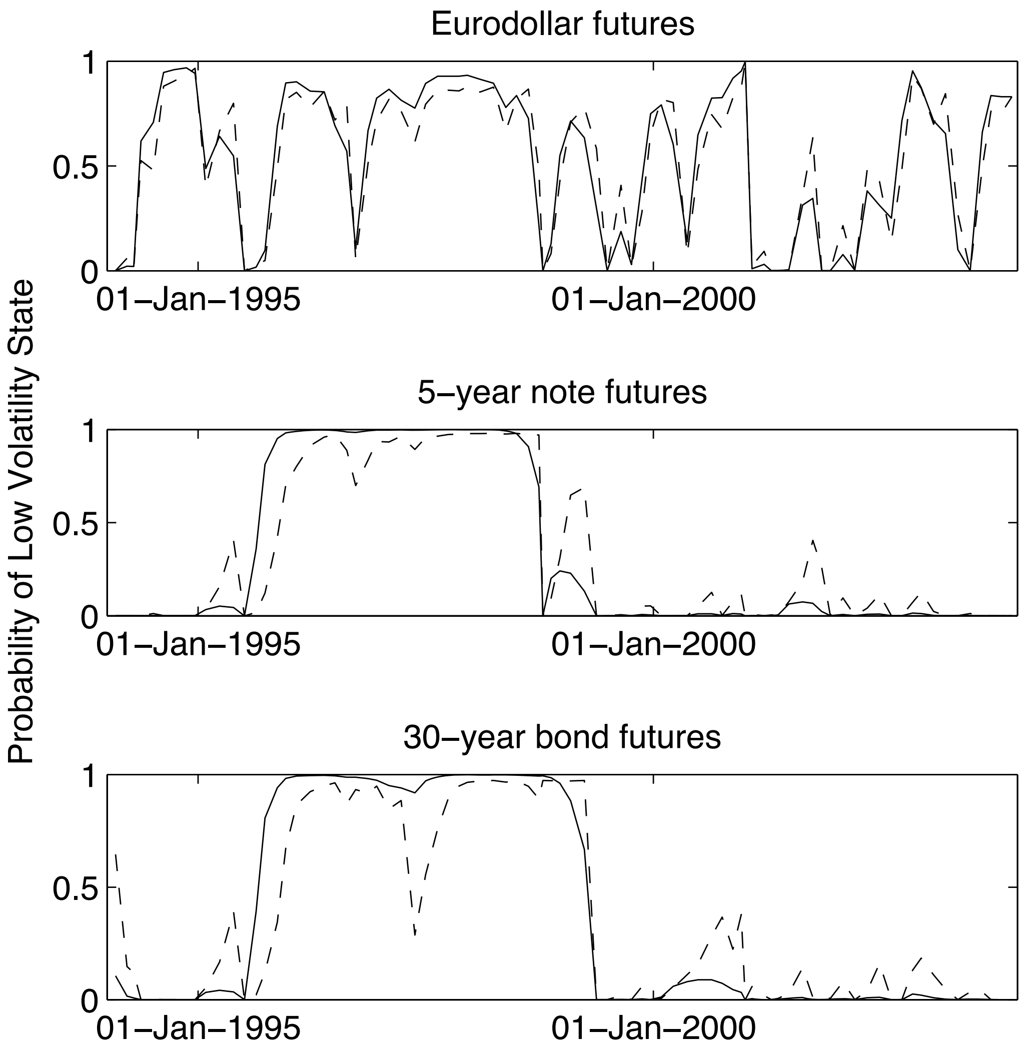

FIGURE 1. Probabilities for the Low-Volatility State (Sample includes intermeeting moves)

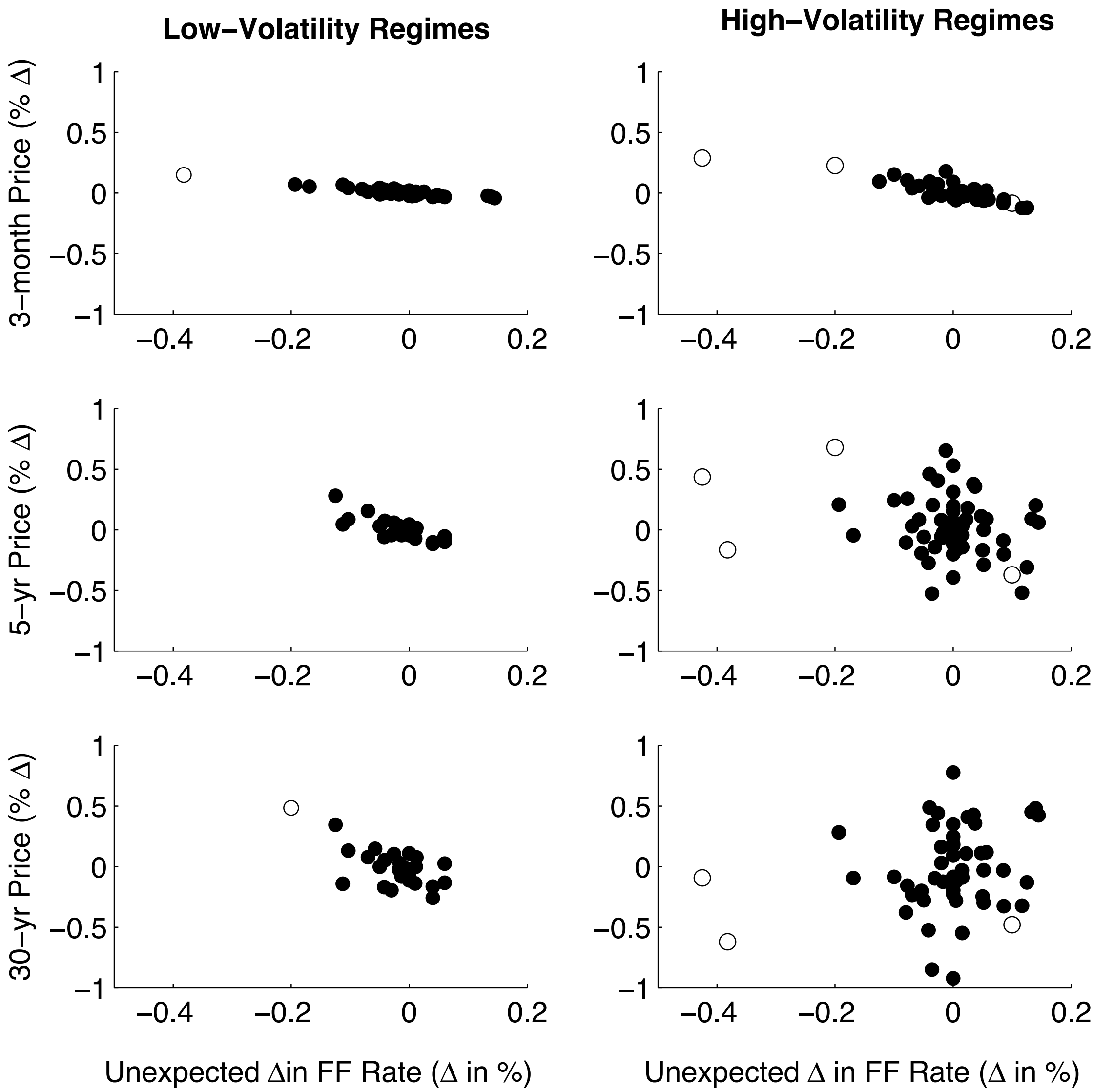

Figure 2. Scatter Plots Conditional on State [Hollow markers denote intermeeting moves.]

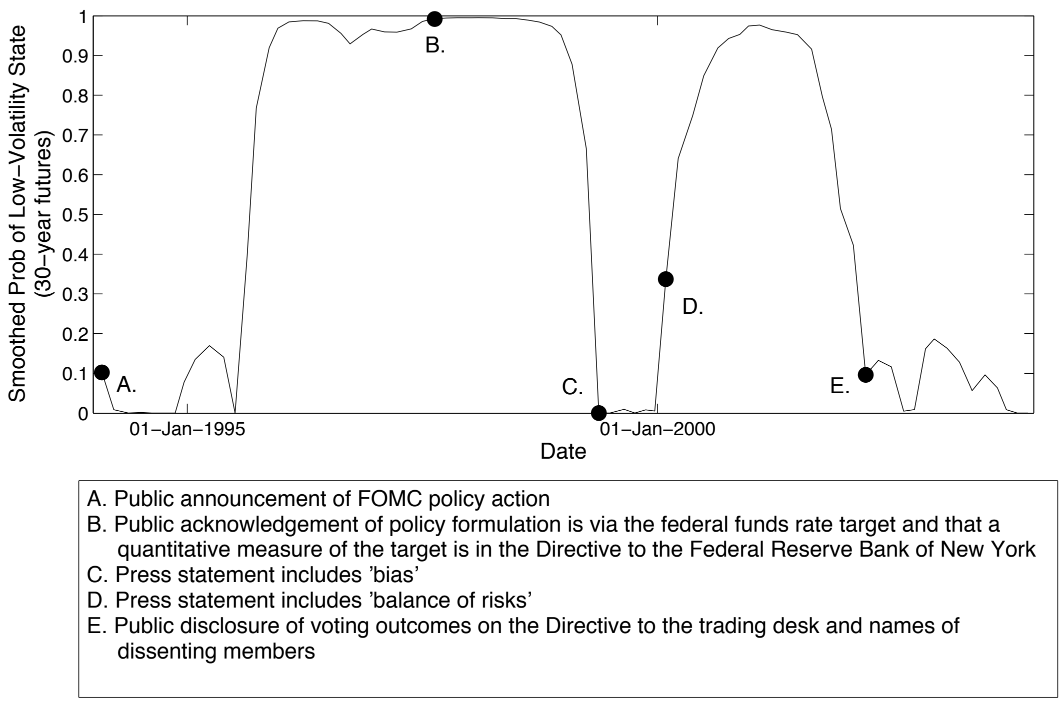

FIGURE 3. Smoothed probability of being in the low-volatility state for the 30-year futures. Bullet points denote changes in Fed communication policy identified by Poole and Rasche (2003)