An Investigation of the Forward Looking Behavior in Equity Markets: Responsiveness to Monetary Policy

Selva Demiralp

and

Kamil Yilmaz

Koc University
Istanbul, Turkey

December 2008

Abstract

This paper analyzes the recent changes in the responsiveness of equity markets to monetary policy actions. In an era of increased transparency and expanded communication in policy making, equity markets should also become more forward looking. That is, they should respond not only to current interest rate changes but also to changes in the future path of policy. Using federal funds futures contracts to extract policy expectations, we find strong support for a forward looking behavior in equity market's reaction to monetary policy. Furthermore, we document a drastic increase in the responsiveness of the stock market to monetary policy actions over time.

Keywords: Monetary policy expectations, wealth channel, equity markets

JEL Codes: E44, E52

1. Introduction

Over the last decade, the Federal Reserve took significant steps towards transparency. These steps allowed the Fed to expand its tools available for policy making. While interest rates have been the primary operational tool that reflected changes in the policy stance until 1999, policy statements that accompanied interest rate announcements after this date informed the market participants not only about the current policy changes but also about the future path of monetary policy. These developments allowed market participants to better understand the decision making process of the policy makers and form more accurate forecasts of future policy actions, which speeded up the traditional channels of the monetary transmission mechanism.

In this paper, we explore the changes in the traditional wealth channel of the monetary transmission mechanism that came about due to more transparent policy making. The textbook description of the wealth channel argues that expansionary monetary policy increases the money supply and leaves the public with more money than it wants. The consequent rise in spending increases the demand for stocks and hence raises their prices. Implicit in this description is the long lags in the monetary transmission process. Adjustments in the money supply in response to a change in the policy stance depends on the slow tuning of reservable deposits and required reserve balances on the demand side, which takes at least several months (see Carpenter and Demiralp, 2008). What is missing in this textbook description is the stock market's response to expected monetary policy actions even before the policy decision is announced and any adjustments to monetary aggregates are made. Evidence of this type of an "anticipation effect" in various other markets such as Treasury securities and the interbank market has already been documented in several studies where market rates respond to anticipated monetary policy actions in the weeks prior to a target change (see e.g. Kuttner, 2001, Lange, Sack, Whitesell, 2003, Carpenter and Demiralp, 2006a, among others). Indeed, the volatility of equity markets in the days prior to an FOMC meeting suggests a strong anticipation effect in this market as well, at least since the last decade. Hence, one may argue that the traditional wealth channel gains an addition momentum due to the anticipation effect where the equity markets respond to monetary policy actions even before any changes in the policy stance take place.

Recently, Bernanke and Kuttner (2005) (hereafter BK) investigated the anticipation effect in equity markets by looking at the response of equity prices to unanticipated policy actions. They argued that the market is unlikely to respond to policy actions that were already anticipated and therefore one should distinguish between expected and unexpected policy actions. We take BK's analysis one step further and argue that in an era of increasing transparency in policy making and rising role of expectations in financial markets, it is natural to expect the responsiveness of the stock market to become even more forward looking over time. That is, in addition to the unanticipated component of the current policy action, the markets should also respond to how the expected policy path is revised for future months based on the information they gather from policy statements and other forms of communication such as policy reports, speeches, or news releases. Hence, we measure the stock market's responsiveness to policy actions not only due to the unanticipated component of the current target announcement but also due to how market participants revised their future path of monetary policy.

We extract the current as well as future policy surprises based on federal funds futures contracts, using the methodology described in Demiralp (2008). Our results document evidence of a forward looking behavior in the stock market where market participants respond not only to unanticipated changes associated with the current target announcement but also and largely to revisions in the future policy path based on policy statements. This should not be interpreted as current policy actions are becoming secondary but that their influence comes earlier when investors build in expectations of those actions.

In addition to documenting the forward looking behavior in stock market reaction to monetary policy decisions, we also analyze the evolution of this reaction for the first time in the literature. Using the rolling regressions framework, we are able to document a significant change in the responsiveness of the stock market to monetary policy decisions over time.

The rest of the paper is organized as follows: In the next section we describe the methodology that allows us to obtain measures of monetary policy expectations and provide summary statistics for these measures. Section three discusses the issues regarding the liquidity in the federal funds market. Section four presents the empirical results while section five concludes.

2. Measuring Market Expectations

Kuttner (2001) used a market-based measure to identify unexpected funds rate changes based on the price of federal funds futures contracts, which contain information on the expectations of the effective funds rate averaged over the settlement month. Demiralp (2008) extended this analysis to extract information about market expectations up to three months into the future based on one-month, two-month and three-month futures contracts. The analysis in this paper uses a similar method to gauge the revisions in the policy path in the future months.

In order to estimate revisions in the policy path, we need to understand how the target change on day *t* affects policy expectations for the future months. We assume the market expects the average overnight rate for a given month to be equal to the funds rate target as in Kuttner (2001). This assumption is strongly supported by the data as daily deviations from the target are only temporary (see Carpenter and Demiralp, 2006a). Furthermore, we assume that on the day of a target change *t*, future policy changes are only expected on regularly scheduled FOMC days.

A target change on day *t* may take place on a regularly scheduled FOMC meeting day or it may be an intermeeting decision. If there is an FOMC meeting on day *t*, two possibilities exist for the next month: there may be an FOMC meeting, or there may not be an FOMC meeting. If there is no FOMC meeting in the next month, then, there has to be an FOMC meeting in the following month. Alternatively, if there was an FOMC meeting in the next month, then, there may or may not be a meeting in the following month provided that a scheduled meeting is not the fourth meeting in the last four months because FOMC meetings are not scheduled for more than three consecutive months.

Market Expectations in Month 1

As described in Kuttner (2001), the interest rate of the federal funds futures contract on a particular day *t* reflects the expected average funds rate for that month, conditional on the information prevailing up to that date.[1] Based on this fact and knowing that the effective funds rate as a monthly average is very close to the target rate (typically within a few basis points), the current month (or “spot-month”) futures rate (*FF*1) on the day before a target change can be expressed as:

[1] Naturally, this measure presumes that market participants are aware of the target and can observe the changes. If the market participants were unaware that the target had changed, expectations would not necessarily reflect the changes in the policy instrument.

$$FF1_{t-1} = \frac{t \times T_0 + (m_1 - t) \times E_{t-1}(T_1)}{m_1} + \mu_{t-1} \tag{1}$$

where T_0 is the funds rate target on day t-1, T_1 is the funds rate target on day *t*, E_{t-1} is the expectations operator based on information as of day *t*-1, and μ_{t-1} is a term that may represent the risk premium or day of month effects in the futures market. In an efficient market with risk-neutral investors, this term would be zero. m_1 is the total number of days in month 1.

Assuming that the target change occurs on day *t*, the spot rate (*FF*1) on day *t* is given by:

$$FF1_t = \frac{t \times T_0 + (m_1 - t) \times T_1}{m_1} + \mu_t \tag{2}$$

The difference between the spot-month rates prior to and after the target change i.e. (2)-(1), gives us the policy surprise for the current month ($Surprise_1$) as of day *t* assuming that the term premium remains constant:

$$(FF1)_t - (FF1)_{t-1} = \Phi[\underbrace{T_1 - E_{t-1}(T_1)}_{Surprise_1}], \text{ where } \Phi = \left(\frac{m_1 - t}{m_1}\right) \tag{3}$$

Equation (3) is used to compute the policy surprise except for two cases:

1. Kuttner notes that the day-*t* targeting error and the revisions in the expectation of future targeting errors may be non-trivial at the end of the month. Consequently, if a target change occurs in the last five days of the month, the difference in one-month futures rate (FF2) is used to derive the policy surprise since the one-month rate reflects the expected average funds rate for the next month:[2]

[2] To be more precise, Kuttner (2003) considers the "end of month" to be the last three days of the month. We slightly extend this period to include the last five days of the month to eliminate the sensitivity of our results to some target changes that took place in this interval. This is a legitimate generalization because if a target change takes place within the last five days (or the last three days) of

$$(FF2)_t - (FF2)_{t-1} = \Phi\underbrace{[T_1 - E_{t-1}(T_1)]}_{Surprise_1}, \text{ where } \Phi = \left(\frac{m_1}{m_1}\right) = 1$$

2. If the target change takes place on the first day of the month, we need to use the one-month futures rate from the *previous* month to assess market's expectations on day 1.

$$(FF1)_t - (FF2)_{t-1}^{\text{Previous Month}} = \Phi\underbrace{[T_1 - E_{t-1}(T_1)]}_{Surprise_1}, \text{ where } \Phi = \frac{m_1}{m_1} = 1$$

The calculation of the surprises (or path revisions) for future months follow the same general principle and are discussed next.

Market Expectations in Month 2

a) No FOMC Meeting in Month 2

If there is no FOMC meeting in the second month, then, the policy surprise in that month is the same as the market surprise from the first month ($Surprise_1$):

$$Surprise_2 = Surprise_1$$

b) FOMC meeting on day k of Month 2

If there is an FOMC meeting on day *k* of the next month, then one-month futures contract (*FF*2) as of day *t*-1 (in the current month) is equal to:

$$FF2_{t-1} = \frac{kE_{t-1}(T_1) + (m_2 - k)E_{t-1}(T_2)}{m_2}$$

a given month, then no FOMC meeting is scheduled for the next month in both cases, which is the necessary assumption to make this adjustment. Gürkaynak (2005) applied a similar adjustment for target changes that took place within the last week of the month. In a recent paper, Hamilton (2008) points out the elevated end-of-month volatility in the federal funds rate and highlights that the underlying assumption about the funds rate being equal to target may fail towards the end of the month, which supports our month-end adjustment for an extended interval.

where T_1 is the funds rate target as of day *t* in month one, T_2 is the funds rate target after day *k* in month two, E is the expectations operator, and m_2 is the number of days in month 2.

Taking the difference between the price of the one-month contract between days *t* and *t*-1:

$$FF2_t - FF2_{t-1} = \frac{k}{m_2}[T_1 - E_{t-1}(T_1)] + \frac{m_2 - k}{m_2}[E_t(T_2) - E_{t-1}(T_2)] \tag{4}$$

Solving for the second term on the right hand side:

$$\underbrace{E_t(T_2) - E_{t-1}(T_2)}_{Surprise_2} = \frac{m_2}{m_2 - k}\left[(FF2_t - FF2_{t-1}) - \frac{k}{m_2}\underbrace{[T_1 - E_{t-1}(T_1)]}_{Surprise_1}\right] \tag{5}$$

The term on the left hand side in equation (5) gives the market surprise for the second month ($Surprise_2$) which is related to the surprise from the first month. The intuition is rather simple: total change in one-month futures rate on day *t* consists of two parts: revisions in expectations for overnight rates that are expected to prevail until day *k* of next month (which is the market surprise for the current target change), and revisions in expectations for overnight rates that are expected to prevail after day *k* next month ($Surprise_2$). Hence, we can identify the remainder of the market surprise for the next month by subtracting current month's surprise from the total revision.

Equation (5) is used to obtain the market surprise for most days of the month except for:

i. If an FOMC meeting is scheduled in the last five days of the *next* month (i.e. $m_2 - k < 5$), the difference in the two-month futures rate is used to derive the policy surprise since it reflects the expected average funds rate for the following month:

$$(FF3)_t - (FF3)_{t-1} = \Phi[\underbrace{T_2 - E_{t-1}(T_2)}_{Surprise_2}], \text{ where } \Phi = 1 \tag{6}$$

ii. If the target change takes place on the first day of the *current* month (i.e. $t = 1$), we use the two-month futures rate from the *previous* month to assess market's expectations on day 1.

$$(FF2)_t - (FF3)_{t-1}^{\text{Previous Month}} = \Phi[\underbrace{T_2 - E_{t-1}(T_2)}_{Surprise_2}], \text{ where } \Phi = 1 \tag{7}$$

iii. If the target change takes place on the first day of the *current* month (i.e. $t = 1$) *and* if an FOMC meeting is scheduled in the last five days of the *next* month (i.e. $m_2 - k < 5$), the difference in the two-month futures rate and the three month futures rate from the previous month is used to derive the policy surprise:

$$(FF3)_t - (FF4)_{t-1}^{\text{Previous Month}} = \Phi[\underbrace{T_2 - E_{t-1}(T_2)}_{Surprise_2}], \text{ where } \Phi = 1 \tag{8}$$

Market Expectations in Month 3

a) No FOMC meeting in Month 3

If there is no FOMC meeting in the third month, then, the policy surprise in that month is the same as the surprise from the second month:

$$Surprise_3 = Surprise_2$$

b) FOMC meeting on day k of Month 3

Market surprise is calculated analogous to equation (5), but this time utilizing the two-month futures contract (*FF*3) as opposed to one-month:

$$\underbrace{E_t(T_3)-E_{t-1}(T_3)}_{Surprise_3}=\frac{m_3}{m_3-k}\left[(FF3_t-FF3_{t-1})-\frac{k}{m_3}\underbrace{[E_t(T_2)-E_{t-1}(T_2)]}_{Surprise_2}\right] \tag{9}$$

In the special cases the market surprise is calculated with the following adjustments:

$Surprise_3 = FF3_t - FF4_{t-1}$, for the first day of the current month, and

$Surprise_3 = FF4_t - FF4_{t-1}$, for the last five days of the third month.

$Surprise_3 = FF4_t - FF5_{t-1}$, for the first day of the current month and the last five days of the third month.

Market Expectations in Month j

The above methodology can be extended to any month *j* into the future such that:

If there is no FOMC meeting in month *j*, then $Surprise_j = Surprise_{j-1}$

If there is an FOMC meeting on day *k* of month *j*, then

$$\underbrace{E_t(T_j)-E_{t-1}(T_j)}_{Surprise_j}=\frac{m_j}{m_j-k}\left[(FFJ_t-FFJ_{t-1})-\frac{k}{m_j}(Surprise_{j-1})\right] \tag{10}$$

In the special cases the market surprise is calculated as follows:

$Surprise_j = FFJ_t - FF(J+1)_{t-1}$, if t=1, and

$Surprise_j = FF(J+1)_t - FF(J+1)_{t-1}$, for the last five days of month *j*.

$Surprise_j = FF(J+1)_t - FF(J+2)_{t-1}$, if the target change takes place on the first day of the current month (i.e. $t = 1$) *and* an FOMC meeting is scheduled on the last days of month *j* (i.e. $m_j - k < 5$).

Intermeeting changes with FOMC meeting later in the month

Using the above methodology, policy revisions for the current month as well as future months can be calculated for each target change except for intermeeting changes followed by an FOMC meeting in the same month. In the latter case, one has to impose additional assumptions which may be questionable. To illustrate this point, suppose there is an intermeeting change on day *t* with an FOMC meeting scheduled later in the month on day *k*, such that *k*> *t*.

The spot-month contract on day *t*-1 reflects the average funds rate expected in that month:

$$FF1_{t-1} = \frac{tT_0 + (k-t)E_{t-1}(T_1) + (m_1 - k)E_{t-1}(T_2)}{m_1} \tag{11}$$

where:

T_0 is the target prior to the intermeeting change, T_1 is the target after the intermeeting change until the FOMC day, and T_2 is the target after the FOMC day. If the market does not anticipate an intermeeting change, then $E_{t-1}(T_1) = T_0$. If there are no further changes after the intermeeting change, then $T_1 = T_2$.

On the day of the intermeeting change, the price of the spot month contract is equal to:

$$FF1_t = \frac{tT_0 + (k-t)(T_1) + (m-k)E_t(T_2)}{m} \tag{12}$$

Taking the difference between the price of the spot-month contract between days *t* and *t*-1:

$$FF1_t - FF1_{t-1} = \frac{(k-t)\left[T_1 - E_{t-1}(T_1)\right] + (m-k)\left[E_t(T_2) - E_{t-1}(T_2)\right]}{m} \tag{13}$$

In (13), the first term in the numerator reflects the unanticipated component of the target after the intermeeting change while the second term reflects the revision in expectations for the target after the FOMC meeting. Therefore, unless $E_t(T_2) = E_{t-1}(T_2)$, the second term is nonzero and one cannot identify the unanticipated component of the target after the intermeeting change. The second term will only be equal to zero if the market does not revise the target level expected after the FOMC meeting. That is, there has to be perfect foresight such that the market participants correctly anticipate the level of the target after the FOMC meeting. While it may be plausible under certain scenarios, this is a stronger assumption and we check the robustness of our findings by excluding these observations from the sample in our empirical analysis.

Path Revisions

Our methodology of calculating policy surprises for each month *i* into the future allows us to estimate average path revisions over a particular period. Indeed, if financial markets are rational and forward looking, we would expect them to respond to average changes in the policy path in the "foreseeable future" rather than to the surprise series for a particular month, consistent with the Federal Reserve's signals about changes in the policy path.

Path revisions are estimated in the following manner. Recall that m_j is the number of days in month *j* and let cum_i be the cumulative sum of days in an *i* month period such that $cum_i = \sum_{j=1}^{i} m_j$. Furthermore, let t_1 be the day of a target change in month 1 and t_j be the day of an FOMC meeting in month *j*, $j>1$. Then,

$$R_2 = \frac{1}{cum_2}\left[(m_1 - t_1 + t_2) \times Surprise_1 + (m_2 - t_2) \times Surprise_2\right] \tag{14}$$

and

$$R_3 = \frac{1}{cum_3}\begin{bmatrix}(m_1 - t_1 + t_2) \times Surprise_1 + (m_2 - t_2 + t_3) \times Surprise_2 \\ + (m_3 - t_3) \times Surprise_3\end{bmatrix} \tag{15}$$

where R_i refers to the total path revision in the *i* month period into the future.

Figure 1 plots the 60-month moving averages of the absolute surprise series as well as path revisions. This figure highlights several interesting observations. First, most of the series exhibit a clear downwards trend, suggesting improvements in anticipated monetary policy actions across all horizons over time, consistent with the steps towards transparency. Second, revision surprises lie consistently below the surprise series associated with individual months. This result is expected because market surprise is frequently about the timing of an expected policy action which is either postponed or moved earlier due to the current decision. Hence, over a two or three-month horizon, these timing adjustments cancel each other off, resulting in a smaller path revision. In the empirical analysis, we expect the stock market's response to move inversely with the size of the surprise series. That is, the smaller is the market surprise, the stronger should be the stock market's reaction to that surprise. We can think of at least two hypotheses that would lead to result. First, if policy changes in the later period were perceived to be more persistent, it would lead to a stronger market response. Second, we can think of a model with "signal" and "noise" in target changes where smaller surprises would imply less "noise" and relatively more signal. Hence, we may observe a larger response because market participants are more likely to act upon their expectations if they are more confident about them. If this conjecture is true, then we expect to see the following patterns in our empirical findings:

i) Stock market's responsiveness to monetary policy actions should increase over time

ii) The market's responsiveness to path revisions should be larger than its responsiveness to the surprise series associated with each month.

Overall Evaluation

Two issues are important for the reliability of the generalization discussed in this section. The first one is the constancy of the term premium between the consecutive days of a contract for any maturity. In other words, the monetary policy action should not change the term premium from one day to another. In a recent study, Piazzesi and Swanson (2008) tested this assumption formally and illustrated that the above methodology of looking at the one-day changes in the federal funds rate contracts is not contaminated by the term premium because most of the term premium is "differenced out". Sack (2004)'s findings also support this assumption by noting that the term premium for federal funds futures contracts is very small. The second issue regarding the reliability of the methodology is the liquidity of futures contracts for longer maturities. We tackle this issue more formally in the next section and show that the liquidity of futures contracts at longer maturities have increased dramatically over the last decade.

3. Liquidity in the Federal Funds Futures Market

Federal funds futures contracts began trading on the floor of the Chicago Board of Trade (CBOT) in October 1988. These contracts are traded for the current month and for future months. While shorter horizon contracts gained substantial liquidity within a few months after the opening of the market, the liquidity of longer term contracts had been relatively thin in the early part of the sample, which led researchers to express their concerns about using these longer horizon contracts in extracting information on monetary policy expectations (see e.g. Hamilton, 2008, Gurkaynak, 2005, Sack, 2004). Nevertheless, the liquidity of these contracts grew consistently for all horizons since their opening and particularly after the introduction of electronic trading in 2000.

Two measures of liquidity known in the futures trading literature are the trading volume and the futures open interest. The trading volume is defined as the number of contracts traded during a specified period of time such as a day. Open interest is the total number of contracts that are currently "open", that is, contracts that have been traded but not yet liquidated by either an offsetting trade, an exercise, or assignment. Figure 2 shows the average daily volume as well as the end-of month open interest values of federal funds futures contracts for all maturities.[3,4] This figure shows a drastic increase in total volume and open interest after the introduction of electronic trading in 2000. In order to investigate how the relative volumes of contracts with different maturities changed over time, Figure 3 plots the share of each contract in total volume as a 60-month moving average. This figure points out several interesting facts. First, the volume of the one-month forward contract is consistently higher than the volume of the current month's contract for the entire sample. Meanwhile, the two-month forward contract, which was at least as liquid as

[3] The figure displays the aggregated figures which are the sum of pit and electronic trading.
[4] Federal funds futures data (prices, volumes, and open interest) are obtained from CBOT.

the spot month contract in the beginning of the sample, exceeded the spot month contract's share with the introduction of electronic trading in 2000. In fact, this contract became the most widely traded contract by the end of 2005. Looking at the longer maturities, the three-month forward contract, whose share was consistently above ten percent of total volume throughout the sample, exceeded the spot month contract's share by 2004, and one-month forward contract's share by 2007. Even the longer dated contracts (e.g. four-month, five-month, and six-month forward contracts) increased in volume after 2000. Nevertheless, their relative shares were below ten percent for the majority of the sample which would imply lower liquidity particularly prior to 2000 when the overall volume was significantly lower. Based on these observations, we can conclude that contracts with horizons longer than four months are still not as liquid as the shorter maturities and hence they may pose a problem for daily policy analysis. Even though the current volume of the four-month forward contract is higher than the spot month contract, this contract had a lower volume for the majority of the sample period.

The above analysis about the liquidity of federal funds futures contracts suggests that contracts with maturities shorter than four months are very liquid since their establishment and they can be used for extracting policy expectations on a daily basis. Armed with this information, we compute monetary policy surprises and forecast revisions for a horizon up to three months (which only uses information up to four-month forward contracts) and estimate the responsiveness of the stock market to these forward looking expectations in the next section.

4. Empirical Analysis

BK measure the impact of Federal Reserve policy on the stock market by calculating the market's reaction to funds rate changes on the day of the change for a sample from June 1989 through December 2002. The first column in Table 1 replicates the results from their baseline regression where they regress the CRSP value weighted return on the anticipated and unanticipated components of a target change as shown in equation (16).

$$H_t = \alpha + \beta_1 (Anticipated)_t + \beta_2 (Surprise)_t + \varepsilon_t \qquad (16)$$

where H_t is the CRSP value weighted return on day *t*, *Anticipated* refers to the expected monetary policy action, and *Surprise* refers to the unanticipated policy action.

The data for the effective funds rate is obtained from the Board of Governors (Release H.15). The data for the target funds rate before 1994 is also obtained from the Board of Governors and after 1994, is from FOMC transcripts.[5] Because market participants were not informed about target changes until after the target change prior to 1994, we shift the event day forward by one day to adjust for the time market participants were informed about the change. Furthermore, we adjust the timing of several target changes to synchronize the market response with the day of the target change as discussed in Kuttner (2003).

We find that the CRSP value weighted return increases by 4.8% in response to a 1% point surprise rate cut, consistent with BK. The second and the third columns extend their sample through December 2007 and June 2008 respectively. The reason that we extend the sample in two steps is to highlight the presence of outliers in 2008 which change the results dramatically. Indeed, while column 2 simply reinforces the findings of BK for the sample that goes through December 2007, column 3 indicates

[5] The target series prior to 1994 show slight differences relative to the one used by Bernanke and Kuttner (2005).

that neither anticipated nor unanticipated changes are significant if we add another quarter to our sample period.

To determine which observations might have an excessively large effect on the regression results, we compute the influence statistics for each observation as in BK. BK detect the outliers based on equation (16). Different from BK, however, we identify the outliers based on four separate regressions where the surprise for the current month as well as the surprises for the next month, the following month, and three-months forward are considered individually. Equation (17) displays this framework:

$$H_t = \alpha + \beta_1 (Anticipated)_t + \beta_2 (Surprise_i)_t + \varepsilon_t \qquad (17)$$

where $Surprise_i$ refers to the monetary policy surprise for month *i*, such that *i*=1,2,3.[6] Equation (17) is estimated for each surprise series from the current month ($Surprise_1$) through two months into the future ($Surprise_3$).

Table 2 displays these outliers and their influence statistics, all in excess of 0.30. The last column indicates that most of our outliers were also identified by BK based on $Surprise_1$ alone. Meanwhile, the observation on March 20, 2001, which was identified as an outlier by BK, is not detected as an outlier in our extended sample as its highest influence statistic (-0.22 for $Surprise_1$ equation) is less than our 0.30 threshold in absolute value. However, we still included this observation in our list of outliers along with September 4, 1992 (with an influence statistics of 0.27 for $Surprise_3$ equation) and November 16, 1999 (with an influence statistic of 0.13 for $Surprise_1$ equation).

[6] We obtained identical results with an alternative specification without the anticipated component as in Gürkaynak et al. (2005) or Ehrmann and Fratzscher (2004).

While the influence statistics for these observations are less than our threshold value, in our rolling regression estimations we detected some small sample instability emanating from these observations. BK did not detect September 4, 1992 as an outlier, because they did not consider market surprises beyond the current month. On this day, stock market barely changed (-0.2%), even though all our surprise measures were larger than -20 basis points. The absence of a stock market reaction to such a large market surprise was mainly due to the fact that the FOMC decision to cut Fed funds rate target by 25 basis points followed a very weak employment report released on the same day.

November 16, 1999, rate hike corresponded to the last policy move prior to the turn of the century. This was the policy action that ended the tightening cycle and the policy statement released after the meeting signaled this message to market participants. As a result, the stock market registered record high values on that day, despite the contractionary policy action.

Two additional outliers in 2008 are January 22 and March 18 target cuts. The first observation corresponds to a 75 basis point reduction in the funds rate (the biggest cut over 23 years) in response to the global market turmoil on January 21, which was a holiday in US markets. While the rate cut prevented an excessive dip, it could not stop the stock market fall about 1 %. The last outlier corresponds to the 4% rise in the market due to an additional 75 basis points cut by the Fed in an attempt to alleviate the liquidity crunch and to support a rapidly weakening economy.

Table 3 shows the effects of dropping these eleven outliers from our sample. The first column considers the BK sample while the second column shows the updated sample. When we compare the full sample estimates with and without the outliers (Table 1, column three, row three, versus Table 3, column two, row three), we note that the estimated response to policy surprises increases from -2.29 to -3.23 and becomes significant again once we exclude the outliers in 2008. As noted in BK, finding a significant monetary policy response after excluding the outliers suggests that the response of the stock market to monetary policy surprises is not driven by a handful of outliers present in the data.[7]

So far, we have included all target changes from June 1989 to present, in order to follow BK as closely as possible. As we have mentioned through the end of the previous section, however, when the target change takes place on an intermeeting day and if there is an FOMC meeting later in the month, extracting the anticipated and the unanticipated components of the policy decision requires stronger assumptions. Columns three and four in Table 3 exclude these observations from the analysis. There are a total of ten intermeeting changes followed by an FOMC meeting later in the month. The dates of these changes are: August 10, 1989, November 6, 1989, November 14, 1990, December 7, 1990, February 1, 1991, March 8, 1991, August 6, 1991, December 6, 1991, January 3, 2001, and January 22, 2008. Because the last two observations were already detected as outliers, we drop the remaining eight observations which all took place prior to 1992. Comparing row 3 in columns 2 and 4, we note that the coefficient associated with the surprise variable increases over three quarters of a percentage point, suggesting a stronger stock market response to monetary policy surprises when these observations are excluded.

After having established the response of stock returns to current month's policy surprises for an extended sample, we turn to our main goal in this paper, which

[7] Similar to BK, we also check for whether the Fed's policy of announcing target changes since February 1994 has altered the stock market's response to monetary policy as well as the potential endogeneity problem prior to 1994 when some interest rate changes took place on the same day as the employment report. Our findings (not shown) confirm BK where the period after 1994 is not statistically significantly different from the rest of the sample while the employment report is significant and positive which approximately offsets the surprise coefficient.

is to analyze the responsiveness of the stock market to future policy expectations. If the stock market indeed became more forward looking over time, then we would expect the markets to respond to policy surprises beyond the current month. In order to test that claim, we regress CRSP value weighted return on the policy surprises of different horizons as specified in equation (17). Table 4 shows the results from these regressions which indicate that the coefficient estimates associated with the surprise coefficients are of comparable magnitude and they are all significant. The estimated response increases when FOMC meetings that follow intermeeting changes are excluded. Admittedly, it is impossible to identify the market's reaction to each surprise series per se, because the surprise series are related to each other by construction. Nevertheless, the results in Table 4 are suggestive of evidence that market participants pay attention to policy surprises at different horizons separately.

A better way to deal with the issue of correlation among the surprise series may be to consider averaging these surprises and obtaining a total path revision over a time period. If the market participants indeed respond to policy surprises beyond the current month, then the coefficient associated with the current month's surprise should be smaller than the coefficient associated with the path revision over a time period longer than a month. BK emphasize the importance of the future policy path in affecting equity markets and note that "surprises with a more durable effect on policy expectations would naturally tend to have a larger effect on equity prices than those that merely altered the timing of policy actions (p.1235)". BK try to gauge policy surprises' impact on expected future short term interest rates informally by examining the relationship between the surprises and the change in the federal funds futures rates in subsequent months. Because our methodology allows us to estimate the market's revision of the policy path in the future months, we can test this hypothesis formally.

Table 5 shows the results from the regressions where CRSP value weighted return is regressed onto path revisions for the BK sample:

$$H_t = \alpha + \beta_1 (Anticipated)_t + \beta_2 (R_i)_t + \varepsilon_t \qquad i = 2,3 \tag{18}$$

Comparing rows three and four in this table with row three, column one in Table 3, we observe that the coefficients associated with path revisions are about two percentage points larger than the surprise coefficient for the current month for the BK sample and the difference is statistically significant at 95 percent level of confidence. Table 6 repeats the same experiment for the extended sample. Comparing the market's reaction to path revisions (rows three and four) with its reaction to policy surprises for the current month (Table 3, row three, column two) we notice a similar two percentage points spread in favor of path revisions which is again statistically significant. Furthermore, we notice that the market's responsiveness to path revisions are about four percentage points higher for the sample that excludes outliers as well as FOMC meetings that follow intermeeting changes and the difference is statistically significant (Table 3, row 3, column 4 versus Table 6, rows 3 and 4, columns 3 and 4). This suggests that path revisions capture the responsiveness to monetary policy surprises much better than current month's policy surprise.

A Dynamic Perspective

Our analysis in the previous section considered a static framework in analyzing the stock market's reaction to policy surprises. An interesting extension of this analysis would be to investigate the changes in the stock market's responsiveness over time. Indeed, the important steps taken towards transparency of monetary policy over the last two decades would suggest a more futuristic behavior to set in the later half of our sample as market participants could form more accurate expectations about the future path of policy.

There are several milestones in the history of monetary policy making in the US over our sample period. In 1994, the Federal Reserve started announcing a release immediately after it changed the federal funds rate target. In 1995, a release followed not only target changes but every FOMC meeting. In 1999, the content of the release was extended to include a bias statement about the symmetry of the policy directive at the conclusion of each meeting. Since 2000 the Federal Reserve follows the practice of issuing a “balance of risks” statement along with its policy decision after each FOMC meeting. The balance-of-risks statement is intended to indicate an assessment of the balance of risks for heightened inflation pressures or economic weakness over the foreseeable future.

In order to capture the dynamic changes in the responsiveness of the stock market, we first consider 60-month rolling regressions of equation (17) excluding the outliers. Figure 4 plots the coefficient values associated with monetary policy surprises obtained from these regressions that are significant at the 90% level of confidence. The results are quite interesting. The coefficient values hover between -2 and -4 percent in the first half of the sample, similar to the coefficient estimates obtained for the full sample (Table 5, rows three to five). If the market participants behaved myopically, then we would only expect the surprise coefficient for the current month to be significant and the other surprise series to be insignificant. The coefficient estimates on the current-month, one-month ahead and two-month ahead policy surprises are statistically significant for an overwhelming majority of the rolling windows considered.[8]

More importantly, the coefficient estimates follow a strong downward trend especially after the observations for the post-2000 period are included in the rolling windows, as we had expected in the previous section. This downward trend leads to the responsiveness to monetary policy surprises to more than double over the sample period. For example, in the period prior to 2000, stock prices dropped by less than a percentage point in response to a quarter percent surprise increase in the target rate. In contrast, the market declined by almost two percentage points in response to the same policy action towards the end of our sample.

One potential explanation for this observable shift in the responsiveness of the stock market may be related to the introduction of electronic trading in federal funds futures contracts. That is, the deepening of the volume might have allowed the futures market to improve its forecasts of fed funds target rate, resulting in smaller monetary policy surprises over time as documented in previously (see Carpenter and Demiralp, 2006b).[9] As the federal funds futures market improved its monetary policy forecasts, the equity markets might have become more receptive to the information that is extracted from this market.

In order to evaluate how the market responsiveness to policy surprises compare to the receptiveness to policy path revisions, we estimate similar 60-month rolling regressions of equation (18). Figure 5 shows the results from these

[8] Because we have identified (and excluded) the outliers based on our influence statistics, the small sample results based on each rolling window do not exhibit any large fluctuations. Nevertheless, because the outliers are detected based on the full sample and not based on each sub-sample (we believes such a procedure would be rather ad-hoc) it is natural to observe some fluctuations in the coefficient estimates associated with alternative surprise series.

[9] Several other factors have all contributed to smaller surprises such as the steps towards transparency, fewer and smaller changes in the funds rate target, as well as the Desk's adjustment of its reaction function in an era of lower reserve requirements (see Demiralp and Farley, 2005)

regressions. Path revisions are calculated by pooling the information from the current and the future months as described in equations (14) and (15). Figure 5 exhibits a similar downwards trend, reinforcing our finding of an increase in the responsiveness of the stock markets to policy surprises. Furthermore, when we compare the magnitudes of the responses to monthly surprises versus path revisions (Figure 6), we notice that the market's reaction to path revisions are considerably larger than its reaction to policy surprises for the entire sample period and for each rolling window, again consistent with our predictions in the previous section. This is in harmony with our finding that market participants consider the impact of a particular policy action over the near term policy path and the observed market response reflects the response to this policy path rather than just the current month's interest rate decision. In other words, the observed market response is the combined response to the current rate decision as well as the policy statement about the near term policy expectations. In that respect, considering a regression with only the current month's surprise series would omit an important dimension of policy decisions by overlooking their impact on future policy expectations.

Figures 4-6 provided evidence that the US stock market's response to monetary policy surprises and path revisions increased substantially over time. In these figures, the sub-sample window length was kept fixed at sixty observations, and therefore each window captured only a small portion of the overall sample in each regression. One issue with fixed-length rolling windows analysis is the presence of two effects simultaneously at work. As we roll the window, we drop one observation from the beginning of the sub-sample and add another observation to the end of the sub-sample. The presence of these two effects can have a destabilizing effect on the coefficient estimates. In order to control for these effects and check whether our results are robust to them, we consider two alternative experiments: Fixed starting-point rolling end-point windows, and fixed end-point rolling starting-point windows. When the starting-point is fixed, we would expect the coefficient estimates to be more stable as the end-point of the window is rolled over in time. When the end-point of the full sample is reached (i.e. for the last estimation) we should obtain the same coefficient estimates that were reported in Table 4 (rows three to five, columns, one through three) namely -3.23, -3.14, and -3.08 for surprises one through three respectively. As for the fixed end-point rolling starting-point window, we start with the full sample and move the starting-point forward one observation at a time. Different from the previous experiment, this time the first coefficient estimates corresponds to the full sample coefficient estimates. As the starting point is moved forward, observations from the earlier part of the full sample are dropped and the coefficient estimates are expected to increase in absolute as we reach the final window with 60-observations.

The coefficient estimates for the fixed end-point and fixed starting-point rolling windows are plotted in Figures 7 and 8, respectively. Consistent with our expectations, the coefficient estimates increase in size for the fixed end-point experiment (Figure 6) which replicates the strong downward trend that we had obtained in Figure 4. The market response coefficient estimates, which lie between -3 and -4 in windows including data for 1989 and 1990, start to decline as the observations for late 1990s are dropped from the sub-sample windows. The downward trend continues through the end of the sample where the estimated response coefficients more than double in size, hovering around -8.

One difference between Figures 7 and 4 is regarding the statistical significance of the coefficient estimates. In the case of fixed end-point windows all coefficient estimates are significant at the 90 percent confidence level. In the case of fixed-length rolling windows, however, coefficient estimates for Surprise 1 are not statistically significant in sub-sample windows with end-points in October 1999 through May 2002 period. This difference follows from the fact that fixed end-point windows include not only the sixty observations prior to May 2002, but also observations after May 2002 all the way to the end of the full sample.

Figure 8 displays the results for the fixed starting-point rolling windows experiment. The coefficient estimates fluctuate between -2 and -3 as new observations are added to the fixed starting-point sub-sample window. In order to emphasize the stark contrast with Figure 7, we plot the coefficient estimates for the fixed starting-point window over the same range as the one used in Figure 7. In contrast to Figure 7, the coefficient estimates do not follow any time trend. As long as the observations for the 1990s are included in the sub-sample windows they have significant influence on regressions results, keeping the coefficient estimates between -3 and -2. Including more recent observations in fixed starting-point windows does not change the coefficient estimates in a significant way.

Figures 7 and 8 do strongly support our findings from fixed-length windows (Figure 4 and 5) that the stock market’s responsiveness to monetary policy surprises has substantially increased over time. Regressions with fixed end-point sub-sample windows show that as the early observations are dropped out of the sample, the stock market’s reaction to policy surprises tend to increase in magnitude. Results from the fixed starting-point windows, on the other hand, reveal that as long as the earlier observations are included in the sample window they have an overwhelming influence on the estimates of the stock market responsiveness parameter, keeping it almost unchanged.

Conclusions

Bernanke and Kuttner (2002) had documented a strong and consistent response of the stock market to unexpected monetary policy actions using federal funds futures data to gauge policy expectations. They estimated a ¾ % decline in the CRSP value-weighted index in response to an unexpected 25 basis point cut in the funds rate target (excluding outliers). In this paper, we extended their analysis to incorporate longer term policy expectations. We have shown evidence of a larger market response to policy changes that are perceived to be relatively more permanent by documenting the market's responsiveness to two- and three-months policy path revisions. In particular, we estimated about a 1 ½ % decline in the CRSP value-weighted index in response to an unanticipated 25 basis point path revision.[10] As for the policy implications of this finding, the sizable effect of path revisions suggests that the FOMC may credibly commit to future plans for the federal funds rate.

In another contribution we also show overwhelming evidence of increased stock market responsiveness to monetary policy surprise and/or monetary policy path revisions. From around a value of 2-3 in absolute terms in the early 1990s, the estimated stock market's responsiveness coefficient increases to around 5-6 as the observations for early 2000s included and to around 8 as the observations for 2007 and 2008 are included in the sample. While in the 1990s the stock prices increased by two-three quarters of a percent in response to a 25-basis points surprise cut in fed funds rate target, they can go up as much as 2 percent nowadays. This important

[10] The relative share of the current month's surprise in the path revisions can be calculated based on equations (18) and (19).

result is consistent with the downward trend in monetary policy surprises which is an outcome of increased transparency in monetary policy.

References

Bernanke, Ben and Kenneth Kuttner, 2005, "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *The Journal of Finance*, Vol. 60, No.3, 1221-1257

Carpenter, Seth and Selva Demiralp, 2006a, "The Liquidity Effect in the Federal Funds Market: Evidence from Daily Open Market Operations," *Journal of Money, Credit, and Banking*, Vol. 38, 901-920

Carpenter, Seth and Selva Demiralp, 2006b, "Anticipation of Monetary Policy and Open Market Operations," *International Journal of Central Banking*, June, 25-63

Carpenter, Seth and Selva Demiralp, 2008, The Liquidity Effect at the Federal Funds Market: Evidence at the Monthly Frequency, *Journal of Money, Credit, and Banking, Vol.* 40, February 2008, 1-24

Demiralp, Selva, 2008, "Monetary Policy Surprises and the Expectations Hypothesis at the Short End of the Yield Curve," Economics Letters, Vol. 101, October, 1-3.

Demiralp, S., Farley, D., 2005. Declining Required Reserves, Funds Rate Volatility, and Open Market Operations. Journal of Banking and Finance, 29, 1131-1152.

Ehrmann, Michael and Marcel Fratzscher, 2004, Taking Stock: Monetary Policy Transmission to Equity Markets, *Journal of Money, Credit, and Banking*, Vol. 36, 719-737.

Gurkaynak, Refet, 2005, "Using Federal Funds Futures Contracts for Monetary Policy Analysis," Working paper, Board of Governors of the Federal Reserve System

Gurkaynak, Refet, Brian Sack, and Eric Swanson, 2005, "Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, 1 (1), 55-93

Hamilton, James, 2008, "Assessing Monetary Policy Effects using Daily Federal Funds Futures Contracts," Federal Reserve Bank of St. Louis Review, July/August 2008

Kuttner, Kenneth, 2001, "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market," *Journal of Monetary Economics*, 47, pp. 447-76.

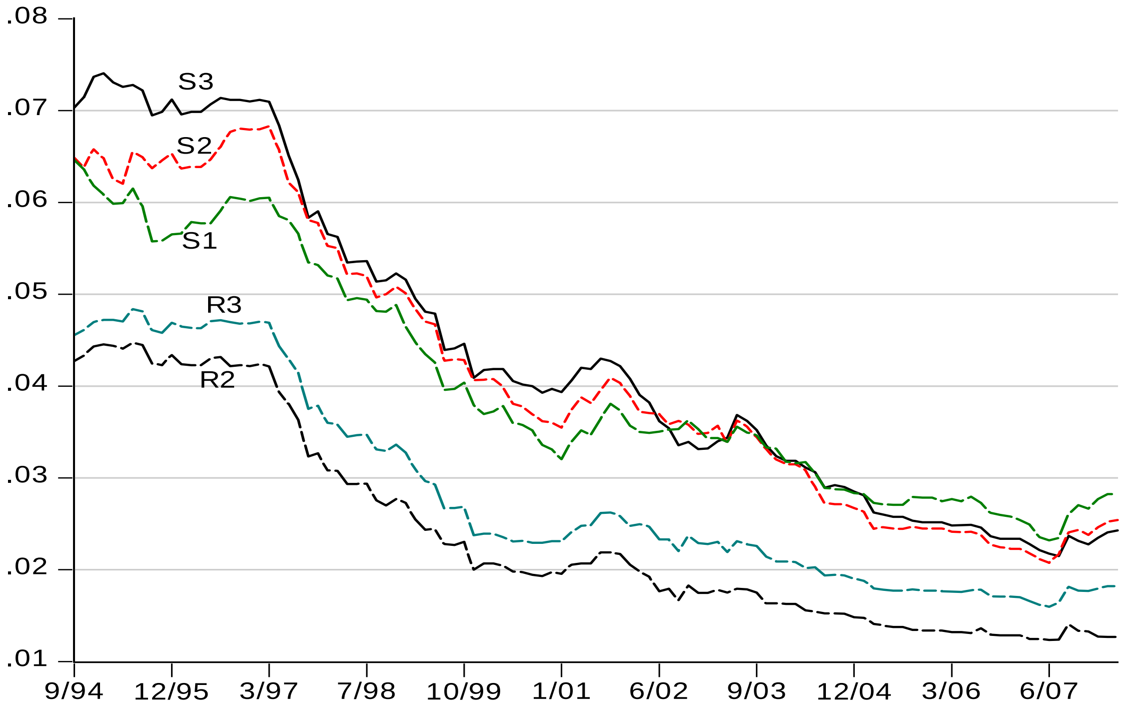
Kuttner, Kenneth, 2003, "Dating Changes in the Federal Funds Rate, 1989-1992," Working paper, Oberlin College

Lange, Joe, Brian Sack, and William Whitesell, 2003, "Anticipations of Monetary Policy in Financial Markets," *Journal of Money, Credit, and Banking,* vol. 35 (December 2003), pp. 889-909.

Piazzesi, Monika and Eric Swanson, 2008, "Futures Prices as Risk-Adjusted Forecasts of Monetary Policy," *Journal of Monetary Economics,* vol. 55 (May 2008), 677-691

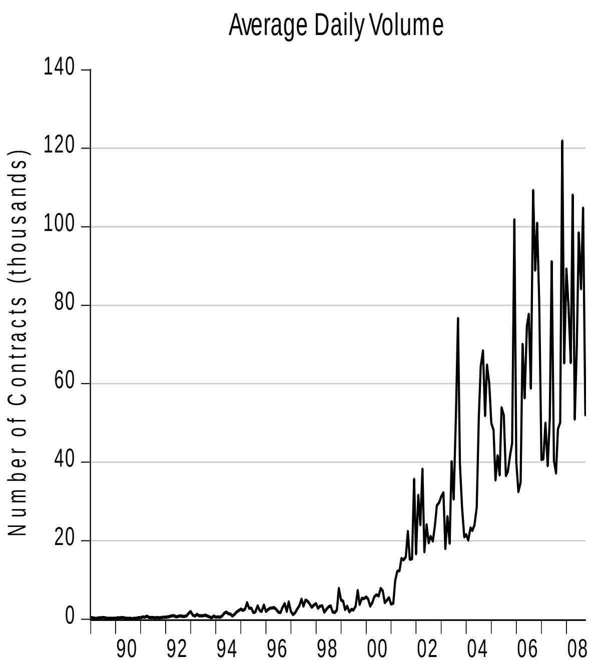
Sack, Brian, 2004, "Extracting the Expected Path of Monetary Policy from Futures Rates," *The Journal of Futures Markets*, 24, No: 8, 733-754

Figure 1: Absolute Monetary Policy Surprises
(60-observation Moving Average)



S1: Surprise 1(Current Month)
S2: Surprise 2(One-month ahead)
S3: Surprise 3 (Two-month ahead)
R2: Revis2 (Current to one-month ahead revision)
R3: Revis3 (Current to two-month ahead revision)

Figure 2: Market for the Federal Funds Rate Futures –
Average Daily Volume and End-of-Month Open Interest (1989:01-2008:10)



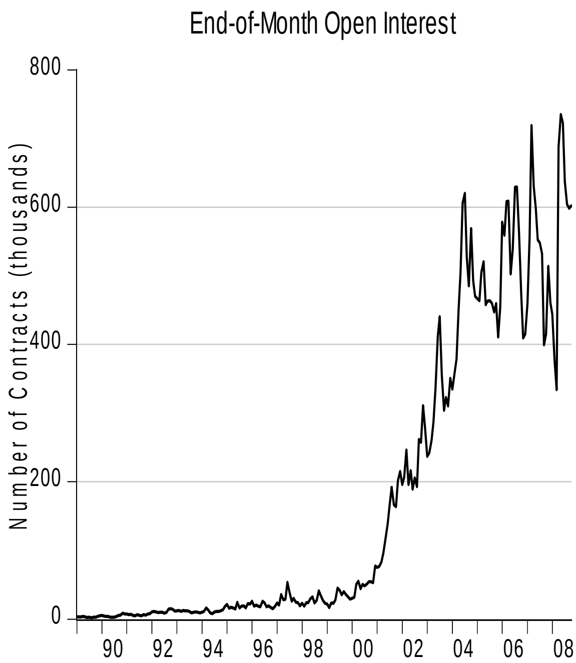


Figure 3: Share of Each Contract in Total Market Volume
(60-month Average; 1989:05-2008:06)

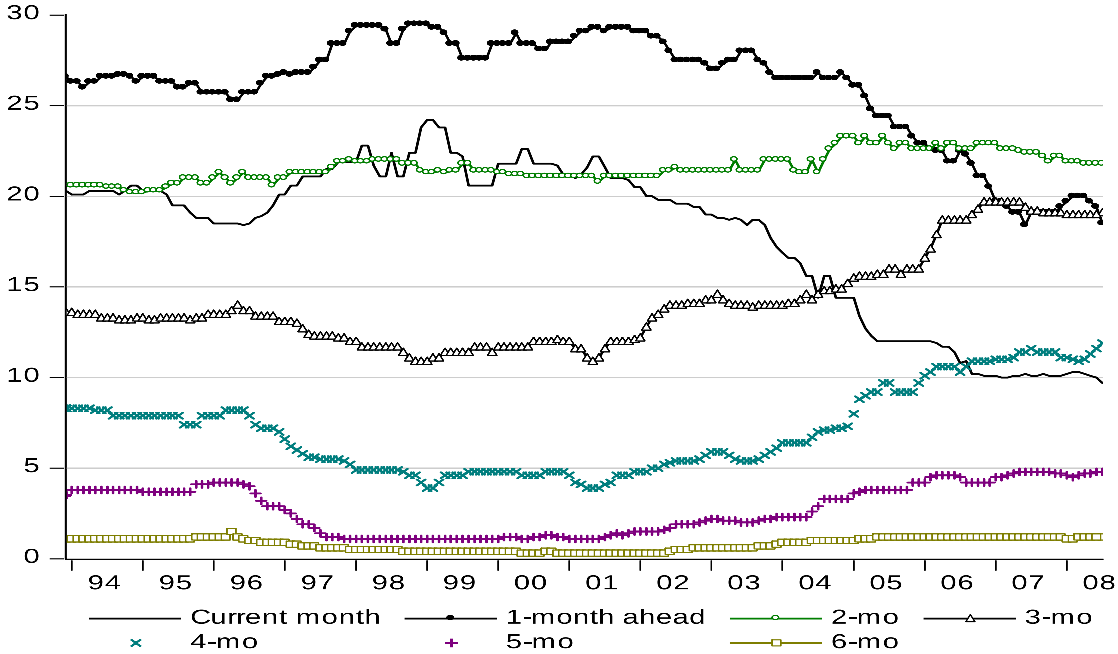


Figure 4: Stock Market Response to Monetary Policy Surprises (60-observation Rolling Windows; 1989:06-2008:06)

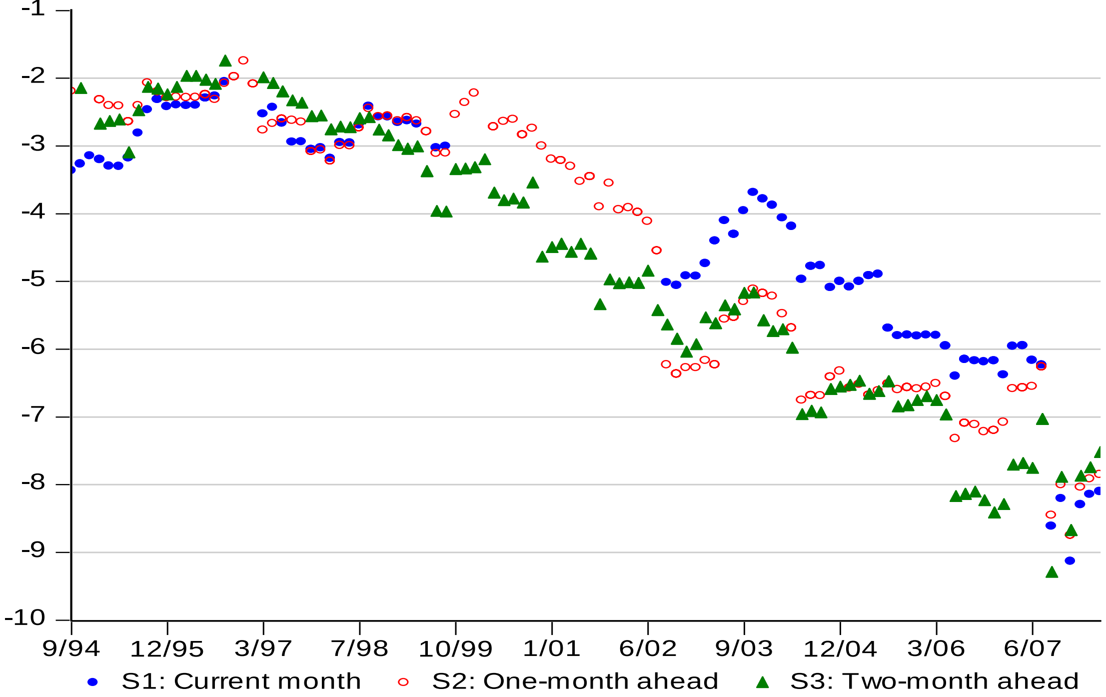


Figure 5: Stock Market Response to Monetary Policy Path Revisions (60-observation Rolling Windows; 1989:06-2008:06)

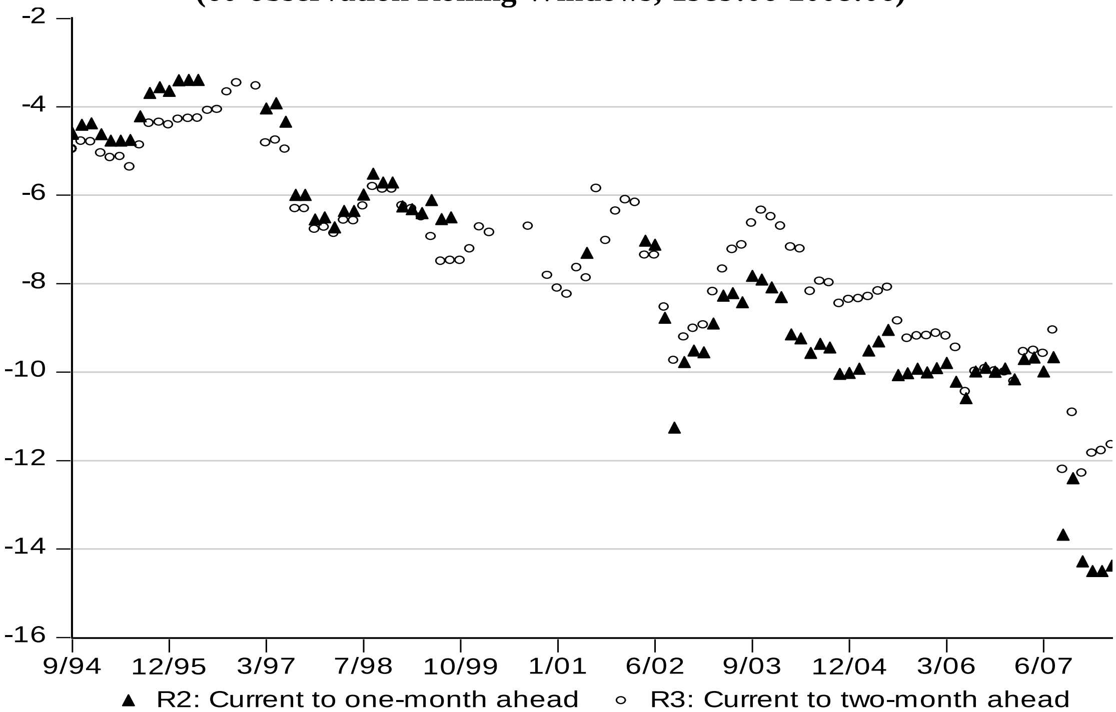


Figure 6: Stock Market Response to Monetary Policy Surprises and Path Revisions

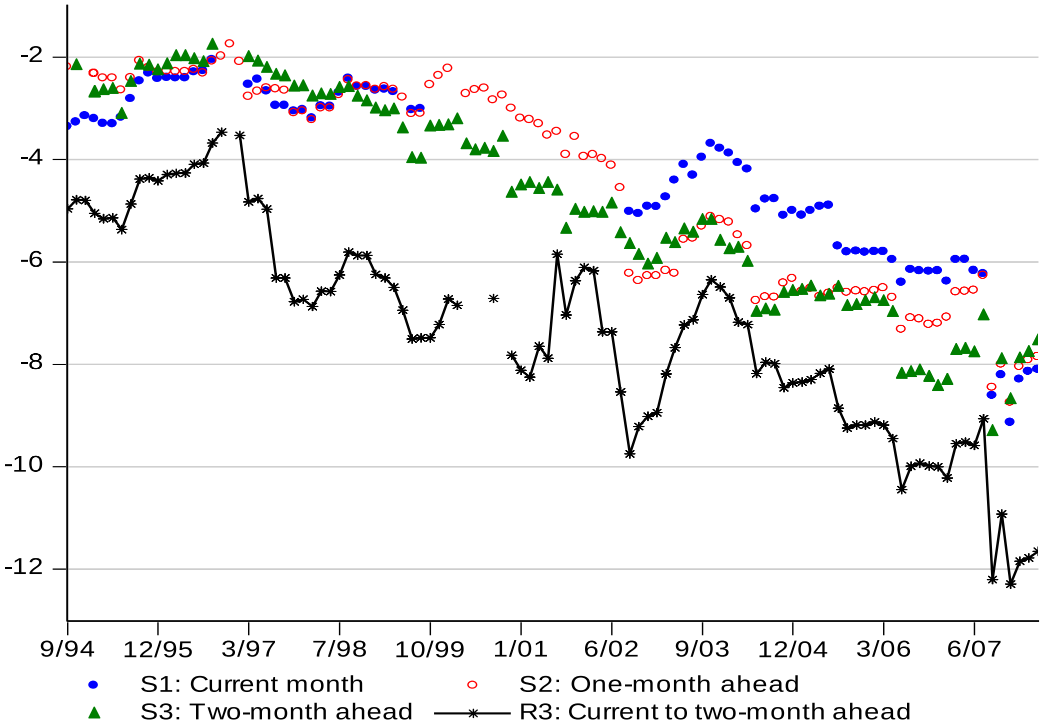


Figure 7: Stock Market Response to Monetary Policy Surprises (Fixed End-Point Rolling Windows; 1989:06-2008:06)

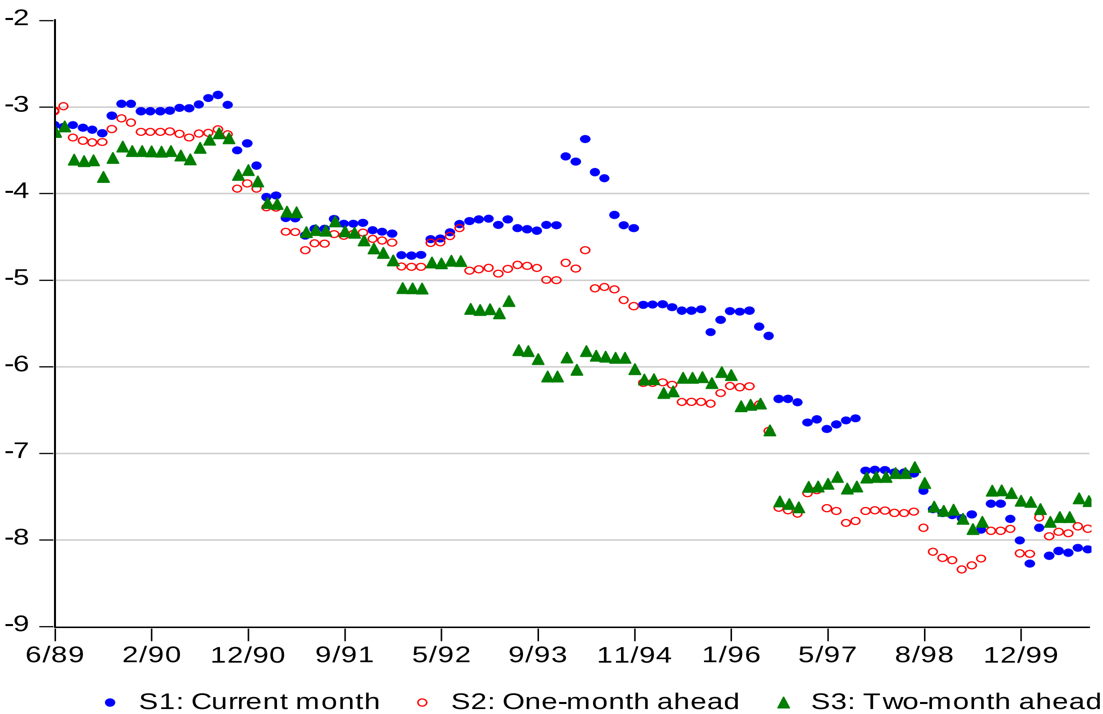


Figure 8: Stock Market Response to Monetary Policy Surprises
(Fixed Starting-Point Rolling Windows; 1989:06-2008:06)

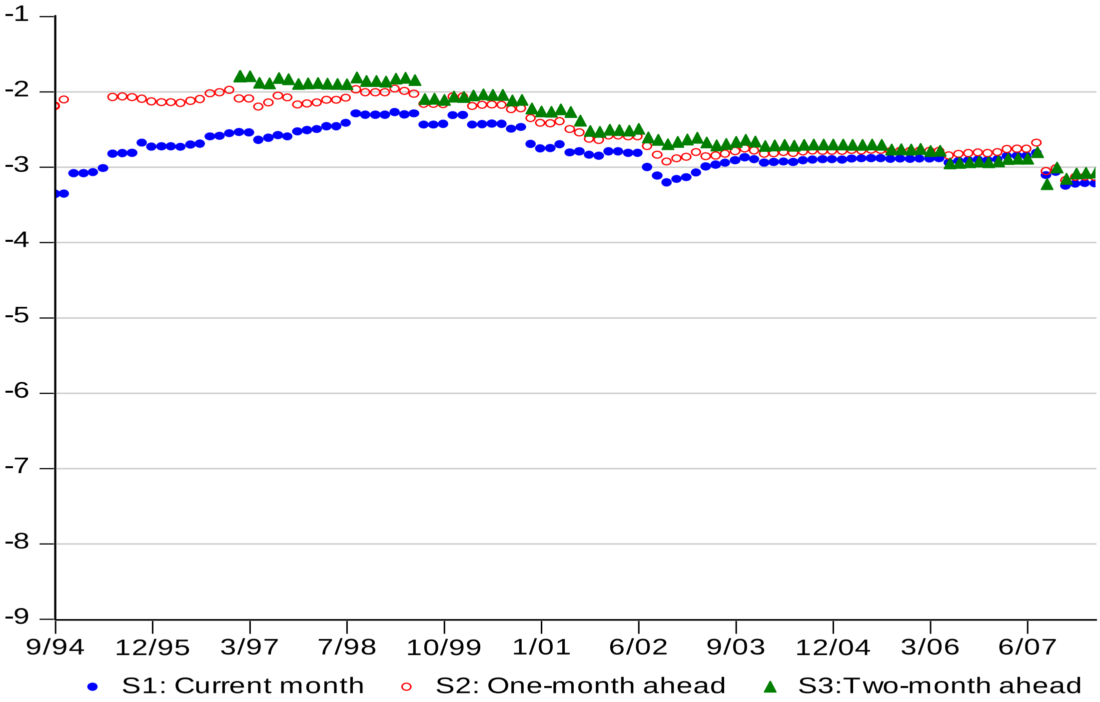


Table 1: Full Sample

Dependent Variable: CRSP daily return	I 1989-2002	II 1989-2007	III 1989-2008
1. Intercept	0.13	0.16**	0.22**
	1.48	2.09	2.74
2. Expected Change	1.10**	0.78**	-0.08
	2.26	1.77	-0.10
3. Surprise Change	-4.84**	-4.77**	-2.29
	-3.04	-3.18	-1.35
4. Number of observations	132	172	177
5. R^2	0.19	0.16	0.05

Note: **/* reflect significance at 95% and 90% level of significance respectively

Table 2: Detecting Outliers Using Influence Statistics

Date	**Outlier detected by Surprise**	**Influence Statistic**	**Outlier detected in Bernanke and Kuttner**
8/21/1991	1, 2	0.32, 0.32	✓
7/2/1992	1, 4	0.31, 0.34	✓
9/4/1992	3	0.27	
10/15/1998	1, 3, 4	-0.55, -1.15,-1.03	✓
11/16/1999	1, 2, 3	0.13, 0.104, 0.116	
1/3/2001	1, 2	-1.10, -1.21	✓
3/20/2001	1, 2, 3	-0.22, -0.21, 0.13	✓
4/18/2001	1, 2, 3, 4	-0.82, -0.90, -0.82, -0.74	✓
1/22/2008	1, 2, 4	1.93, 1.91, 0.75	Not in their sample
3/18/2008	1, 2, 3, 4	0.92, 0.97, 1.28, 1.44	Not in their sample

Table 3: Excluding Outliers

Dependent Variable: CRSP daily return	I	II	III	IV
	Excluding Outliers		Excluding Outliers and FOMC meetings that follow intermeeting changes	
	1989-2002	1989-2008	1989-2002	1989-2008
1. Intercept	0.10	0.14**	0.10	0.14*
	1.28	2.00	1.19	1.94
2. Expected Change	0.68	0.56	0.77*	0.61
	1.60	1.43	1.81	1.54
3. Surprise Change	-3.17**	-3.23**	-4.08**	-4.09**
	-3.26	-3.40	-4.21	-4.24
4. Number of observations	124	167	116	159
5. R^2	0.09	0.07	0.12	0.09

Note: **/* reflect significance at 95% and 90% level of significance respectively

Table 4: Effects of various Surprises (1989-2008, excluding outliers)

Dependent Variable: CRSP daily return	I	II	III	IV	V	VI
	Excluding Outliers			Excluding Outliers and FOMC meetings that follow intermeeting changes		
1. Intercept	0.14**	0.15**	0.16**	0.14*	0.15**	0.17**
	2.00	2.16	2.44	1.94	2.14	2.46
2. Expected Change	0.56	0.51	0.51	0.61	0.54	0.51
	1.43	1.32	1.32	1.54	1.36	1.28
3. $Surprise_1$	-3.23**	--	--	-4.09**	--	--
	-3.40			-4.24		
4. $Surprise_2$	--	-3.14**	--	--	-3.89**	--
		-3.23			-3.88	
5. $Surprise_3$	--		-3.08**	--	--	-3.48**
			-3.08			-3.33
7. Number of obs.	167	167	167	159	159	159
8. R^2	0.07	0.06	0.05	0.09	0.08	0.06

Note: **/* reflect significance at 95% and 90% level of significance respectively

Table 5: Effects of Path Revisions for BK sample (excluding outliers): 1989-2002

Dependent Variable: CRSP daily return	I	II
1. Intercept	0.10 1.34	0.09 1.13
2. Expected Change	0.84* 1.93	0.87** 2.10
3. R_2	-5.07** -2.77	
4. R_3	--	- 5.44** -3.29
5. Number of observations	124	124
6. R^2	0.09	0.12

Note: **/* reflect significance at 95% and 90% level of significance respectively

Table 6: Effects of Path Revisions for the Extended Sample (excluding outliers): 1989-2008

	I	II	III	IV
Dependent Variable: CRSP daily return	Excluding Outliers		Excluding Outliers and FOMC meetings that follow intermeeting changes	
1. Intercept	0.14** 2.02	0.13* 1.87	0.13* 1.84	0.12* 1.71
2. Expected Change	0.67* 1.69	0.70* 1.80	0.86** 2.24	0.84** 2.21
3. R_2	-5.19** -2.81	--	-8.24** -4.50	--
4. R_3	--	-5.46** -3.35	--	-7.98** -5.26
5. Number of observations	167	167	159	161
6. R^2	0.07	0.09	0.11	0.14

Note: **/* reflect significance at 95% and 90% level of significance respectively