

Interest Rate Surprises and Stock Prices

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Abstract

This paper examines the impact of unexpected changes in the federal funds target on stock prices from 1988 to 2001. Measures of interest rate surprises are constructed from survey data and changes in the 3-month T-bill yield. I find that surprises associated with decreases in the target cause stock prices to rise significantly. Surprises associated with increases in the target increase stock market volatility on the announcement day, with volatility reverting to pre-surprise levels on the day after the announcement. This volatility pattern is only evident since 1994. An implication is that concerns about immediate disclosure causing persistent and heightened stock market volatility might be misplaced.

Keywords: Monetary policy; Fed funds rate target; interest rate surprises; survey data; stock market volatility; asymmetric reactions; EGARCH model

JEL Classifications: E44/G12/E65/G18/C22/C51

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1. Introduction

It is widely believed that monetary policy has a significant impact on asset prices. There is also substantial casual evidence that the actions of the Federal Reserve (Fed) affect the expectations of stock market participants. Since Alan Greenspan was appointed Chairman in 1987, the Fed has implemented monetary policy by making discrete adjustments to its target for the federal funds rate. Given that a change in the funds rate target is a monetary policy action, it might be expected that stock prices would react to new information embodied in such changes. Jensen, Johnson and Bauman (1997) and Thorbecke and Alami (1994), cite several studies that have shown that changes in Fed policy influence equity prices. Furthermore, portfolio allocation rules are often predicated on monetary policy, and prominent investment advisors rely on Fed policy as an input in their portfolio selection process. This paper attempts to quantify the marginal impact of surprise changes in the fed funds target on stock prices and on stock market volatility from January 1988 through January 2001.

Interest rate changes affect asset prices to the extent that such changes convey new information about either short- or long-run monetary policy objectives. In particular, interest rate changes can impact equity prices through two channels, i.e. by affecting the rate at which the firm's expected future cash flows will be capitalized, and by altering expectations about future cash flows (Smirlock and Yawitz, 1985). Further, one would expect that if both capitalization rates and expectations about future cash flows are impacted by interest rates, these effects would work in the same direction. In other words, an increase

in interest rates will cause stock prices to decline and a decline in interest rates will cause stock prices to rise.¹

An implication of the efficient markets/rational expectations literature is that asset prices react only to new fundamental information. Pearce and Roley (1985) and Hardouvelis (1987) were among the early researchers to find that stock prices react significantly (and sometimes, primarily) to monetary news or unanticipated monetary policy. However, while the former focused on money supply surprises and announced discount rate and surcharge rate changes, the latter examined unexpected changes in free bank reserves.

Much of the previous research on the effects of monetary policy on stock prices has used changes in the discount rate as a proxy for changes in monetary policy. Smirlock and Yawitz (1985) and Chen *et al.* (1999) decomposed discount rate changes into technical (expected) and non-technical (unexpected) changes based on press releases from the Fed after the rate change. Both studies concluded that unexpected discount rate changes generated a significant announcement effect, and that all of the stock price adjustment to the rate change took place rapidly, by the next day after the announcement at the latest. Chen *et al.* (1999) also examined the effect of discount rate changes on the volatility of stock prices and on trading volume. They found that unexpected discount rate changes contributed to higher, though short-lived, volatility and trading volume.

During Greenspan's tenure as Chairman, the Fed has adopted a policy of targeting inflation by making discrete adjustments to the fed funds rate target. Thus, monetary policy

¹ Hardouvelis (1987) pointed out that the inverse relationship between stock prices and interest rate changes could also be rationalized in terms of money supply surprises. The negative (positive) reaction of stock prices (interest rates) to money supply surprises can be explained in terms of the following two hypotheses. The Expected Real Interest Rate hypothesis claims that stock prices decline because the real component of nominal interest rates is expected to increase, thereby increasing the discount rate at which future cash flows are capitalized and also because higher interest rates affect real output adversely, thereby reducing future operating

is more aptly tracked by changes in this target. Thorbecke (1997) studied the effect of actual changes in the fed funds rate target on the Dow Jones Industrial and Composite averages over the 24 hours bracketing the news of the target change. He found that fed funds target changes were inversely related to stock prices and that monetary policy exerted large effects on ex ante and ex post stock returns. Thorbecke and Alami (1994) got similar results using a sample of fed funds target changes from 1974 to 1979. Neither study attempted to isolate the unexpected component of the target change, nor examine the impact of target changes on stock market volatility.

This study adds to the literature in several ways. To begin with, the Thorbecke (1997) and Thorbecke and Alami (1994) sample is extended in examining the impact of changes in the fed funds rate target on stock prices from January 1988 through January 2001. The anticipated and unanticipated components of the target change are separated using two different techniques. The first approach is based on survey data on market participants' expectations of the funds rate target. The unexpected component (or surprise) is measured as the difference between the actual/announced change in the target and the survey median. This approach, as has been demonstrated in several previous studies, offers a direct assessment of the impact of news contained in the target change announcement on stock prices. The use of survey data circumvents many of the problems associated with the extant approaches to isolating the unanticipated components of interest rate changes made by central banks (Hardy, 1998).² The second technique used to distil the surprise component of target changes utilizes information from the short-end of the Treasury securities market to

cash flows. The Expected Inflation hypothesis claims that stock prices decline because the inflation premium in nominal interest rates increases, which decreases the after-tax real dividends.

gauge the market's expectations of the likely change in the fed funds rate target, drawing on the finding that the 3-month Treasury bill yield fully reflects funds rate target changes (Bonser-Neal *et al.*, 1998). Estimates from using the entire target change as in Bonser-Neal *et al.* (1998) and Thornton (1998) are also reported for purposes of comparison.

I examine the impact on stock prices of the change in the Fed's disclosure policy concerning target changes. Until its February 1994 meeting, the Federal Open Market Committee (FOMC) followed the practice of issuing a policy directive several weeks after the meeting in which a target change had been approved. This delayed announcement policy was based on the idea that immediate disclosure would commit the Fed to a course of action, thereby impairing monetary policy flexibility. Additionally, delayed disclosure, it was argued, would prevent undesirable volatility-generating announcement effects in financial markets. Critics countered that the Fed's failure to convey its intentions to the market in a timely fashion increased uncertainty and volatility. Financial market participants attempted to decipher the Fed's intentions by monitoring the federal funds rate, the Fed's daily open market operations, and Fed "leaks" to the press. Thornton (1996) found that while an announcement effect was evident in market interest rates with or without immediate disclosure, the magnitude of the announcement effect appeared to be smaller with immediate disclosure. Moreover, the announcement effect was strung out over several days when the market was left to decipher policy changes on its own (i.e. pre-1994). I test the impact of unexpected target changes on the stock market and the speed of adjustment of stock prices to such surprises in the two disclosure regimes.

² Previous studies using discount rate changes (Smirlock and Yawitz (1985); Chen *et al.* (1999)) attempted to isolate "news" associated with the rate change announcement based on *ex post* press releases which traders would not have had privy to *ex ante*.

There is evidence that stock prices react differently to bad and good news (Koutmos, 1998, 1999). This asymmetric reaction is supportive of the view that investors have a higher aversion to downside risk, and therefore react faster to bad news. Unexpected changes in the funds rate target, being measured as the difference between the announced value of the target change and the expected change in the target, generate positive (negative) surprises either when the Fed raised rates more (less) than expected or lowered rates less (more) than expected. Consequently, positive surprises could be construed as “bad” news and negative surprises could be viewed as “good” news for stock prices. This study examines, for the first time, the asymmetric stock price responses to positive and negative interest rate surprises.

In recent times, the source of market volatility has attracted a great deal of attention from academic researchers, practitioners and regulators. Not much is known about how funds rate target changes in general affect stock market volatility. This study attempts to quantify the impact of FOMC disclosure policy and differential (positive/negative) interest rate surprises on stock market volatility and enables us to comment on the effect of Fed policy actions on short-term stock market volatility. To do so, an Exponential GARCH (EGARCH) model is employed that captures the peculiar features of high frequency stock price data, namely time-varying volatility, volatility clustering, the leverage effect, excess kurtosis and skewness. This empirical approach facilitates the simultaneous analysis of the effects of interest rate changes on the mean and variance of stock prices.

The rest of this paper is organized in three sections and a conclusion. Section 2 contains a description of the data; I describe the empirical strategy in section 3; Section 4 contains an analysis of the empirical findings.

2. Data

Dates and changes in the federal funds rate target are from Bonser-Neal *et al.* (1998) for 1988-89, and from the Federal Reserve Bank of New York from 1990 through January 2001. There were 60 changes in the federal funds rate target from January 1, 1988 to January 31, 2001 (see the Appendix for details). Where two days were cited for a target change date, e.g. November 13-14, 1990, the later of the two was used as the announcement day. Of the 60 target changes, 26 were increases and 34 were cuts.

The expectations data were obtained from MMS International.³ For the sample studied here, surveys were conducted every week (typically, on Fridays). Till July 3, 1997, survey participants were asked to forecast the level of the Fed funds target (among other variables) during the upcoming two-week Fed statement period. Thus, there were typically two surveys conducted for each statement period, i.e. the first survey at the beginning of the statement period and the second survey one-week into the statement period. Since July 1997, surveys have been conducted relative to forthcoming FOMC meeting dates. There were anywhere from five to eight surveys corresponding to each FOMC meeting date.

The median response from the survey nearest the target change date was used to gauge market expectations concerning target changes. Through to the February 1994 target change, there were 13 occasions on which survey dates coincided with target change dates. To the extent that prior to 1994, the Fed neither disclosed the target change immediately, nor regularly enacted target changes at scheduled FOMC meetings, it is unlikely that survey respondents could have known with certainty the nature or timing of the target change. Consequently, in those cases where the survey date coincided with the target change date

³ MMS International is a subsidiary of Standard and Poor's and conducts surveys of the views of market participants on a wide variety of data releases, both domestic and international.

(excluding the February 1994 target change), that survey was deemed to be the most proximate to the target change.

The unexpected (or surprise) component of the target change was computed as the difference between the actual change in the target and the MMS survey median. In the post-July 1997 period, any target changes made outside of scheduled FOMC meeting dates (i.e. inter-meeting) were treated as surprises. This is because since 1994 the Fed routinely adjusted the target at scheduled FOMC meetings. There were three exceptions: April 18, 1994, October 15, 1998 and January 3, 2001. These were included as surprises on the basis that the market had come to expect target changes to be made at FOMC meetings, and hence these inter-meeting changes were surprises at least in terms of timing, if not in magnitude as well. The survey-based technique yielded 34 total surprises.⁴

The proxy for the stock market used in this study is the S&P 500 index, which is a broader collection of stocks relative to the 30-stock Dow Jones Industrial Average used by previous authors. Data on the 3-month Treasury bill yield were sourced from the Federal Reserve Board of Governors website.

Table 1 contains preliminary statistics on the raw series of daily percentage changes in the S&P 500 Index. The summary statistics suggest that while the sample mean is statistically different from zero, the series is skewed and leptokurtotic relative to the normal distribution. The rejection of normality can be partially attributed to intertemporal dependencies in the moments of the series. There is evidence of serial dependence in the conditional mean and of conditional heteroskedasticity, i.e. the Ljung-Box (LB) statistic is highly significant for both the price change and squared price change series. In fact, the LB

⁴ For the period after July 1997, survey responses around FOMC meeting dates were examined for surprises resulting from FOMC inaction. No additional surprises were found in the dataset.

statistic for the squared series points to significant higher moment dependencies in the data. This is consistent with the autoregressive conditional heteroskedasticity and volatility-clustering characteristic of high-frequency asset price data (Bollerslev, Chou and Kroner, 1992). The summary statistics suggest that a GARCH-class of model would be appropriate, along with an error distribution that allows for greater kurtosis than the normal.

***** Insert Table 1 *****

3. Methodology

Under the maintained hypothesis of efficient markets, the following general model is estimated:

$$\Delta P_t = \alpha + \sum_{i=0}^1 \beta_i \Delta XU_{t-i} + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 \omega_i |\Delta XU_{t-i}| + \sum_{j=1}^m \gamma_j \ln(h_{t-j}^2) + \sum_{k=1}^n \phi_k g(z_{t-k}) \dots \dots \dots (1)$$

where, ΔP_t is the percentage change in the closing values of the S&P 500 index from day $t-1$ to day t^5 , ΔXU are the federal funds rate target surprises, measured in percentage points, and ε_t is a random error. I use two techniques to separate expected and unexpected components of the target changes. The first utilizes survey data to measure market expectations, with surprises computed as the difference between the announced change in the target and the MMS International survey median.

The second measure of target surprises, following Bonser-Neal *et al.* (1998), utilizes information from the short-end of the Treasury market to gauge the market's expectation

concerning likely changes in the fed funds rate target. Accordingly, the expected component of target changes is measured as the change in the 3-month T-bill yield from the day after the previous target change to the day before the current target change. The surprise component was constructed as the difference between the actual target change and this measure of the expected change in the target. The technique yielded 60 total surprises.

It bears noting that using the change in the 3-month T-bill yield as a measure of market expectations is an indirect approach compared to the more direct technique of surveying market participants about their expectations. The 3-month T-bill yield has been shown to reflect fully the change in the target *after* the change occurred (Bonser-Neal *et al.* 1998). However, the yield itself might be affected by a variety of factors peculiar to the Treasury securities market (e.g. order flow, new auctions, etc.) that could make it an imperfect gauge of market expectations regarding an upcoming target change. This intuition is borne out by the fact that all of the (60) target changes were deemed to be surprises using this methodology, compared to 34 when using the survey-based technique.

The conditional variance (h_t) is an EGARCH process that allows for conditional heteroskedasticity, volatility clustering, and the leverage effect, i.e. the phenomenon whereby past negative shocks increase current volatility more than do past positive shocks. The parameter γ captures the persistence in volatility. Standard likelihood ratio lag selection methods suggested an EGARCH(1,1) process was appropriate (i.e. $m=n=1$). Stationarity of the volatility process requires that $\gamma < 1$. The standardized innovation, z_t , is defined as ε_t/h_t such that a positive (negative) z_t implies an unexpected increase (decrease) in stock prices

⁵ We use the percentage change in the index to be consistent with Thorbecke (1997) and Thorbecke and Alami (1994). Results from using the logarithmic difference in the index (as in Chen *et al.*, 1999) yielded similar results.

and, $g(z_t) = \delta z_t + [|z_t| - E|z_t|]$ is an asymmetric function of z_t . The term in brackets relates lagged standardized innovations to volatility in a symmetric fashion, while δ relates standardized innovations to volatility in an asymmetric manner. This specification permits the volatility at time t to depend both on the size and sign of the past standardized residuals or shocks.⁶

The general specification in (1) enables us to test for any announcement day effects of unexpected target change announcements. Theory suggests that stock prices should be inversely related to interest rate changes. Accordingly, one would expect β_0 to be negatively signed. The model also allows us to examine whether the arrival of new public information, affects stock market volatility, via a significance test of the parameter ω_0 . To the extent that any news might reasonably be expected to increase volatility, the sign on ω_0 is expected to be positive.

I also examine the speed with which prices incorporate new information in the target change announcement by assessing the post-announcement reaction of stock prices. Previous studies have shown that stock prices react very quickly to news about monetary policy. Consequently, only a one-day post-announcement window (i.e. a one-period lag structure) is used to examine the speed of adjustment of stock prices. The added advantage of using a narrow time window is that it maximizes our ability to capture the full stock market response to the target surprise, while reducing the possible effects of confounding factors left out of the regression. A failure to reject the null hypothesis that the coefficients of the lags of ΔXU are no different from zero via standard likelihood ratio tests, would be

⁶ The EGARCH model is more general than the standard GARCH model in that it allows innovations of different signs to have a differential impact on volatility and allows bigger shocks to have a larger impact on

tantamount to concluding that all of the stock price adjustment to the target change occurs on the announcement day.

The parametric specification for the conditional probability density used here is the power exponential or Generalized Error Distribution (GED), which includes the normal distribution as a special case. The functional form of the GED density function can be written as:

$$f(\mu_t, h_t, \nu) = \nu / 2 [\Gamma(3/\nu)]^{0.5} [\Gamma(1/\nu)]^{-1.5} (1/h_t) \exp\{-[\Gamma(3/\nu)/\Gamma(1/\nu)]^{\nu/2} |e_t / h_t|^\nu\}$$

where, μ represents the conditional mean, and h the conditional variance of stock prices. $\Gamma(\cdot)$ is the gamma function and ν is a scale parameter controlling the shape of the distribution and is estimated endogenously. For $\nu=2$, the density function is that of the normal distribution. The double exponential ($\nu=1$) and the uniform distribution ($\nu=4$) are also nested within this specification. For values of $\nu < 2$, the GED is more kurtotic than the normal distribution. Maximum likelihood estimates of the parameters were obtained using the Berndt *et al.* (1974) algorithm.

4. Empirical Results

All models were estimated with a Newey-West correction for autocorrelation using ten lags. Each model was also estimated with control variables for the day-of-the-week anomaly. However, these terms were consistently insignificant and were dropped from the final model. Other model specification experiments included the use of MA(1), AR(1) and ARMA(1,1) terms. None was statistically significant.

volatility than does the standard GARCH model. Also, by modeling the logarithm of the conditional variance, it

4.1. Impact of federal funds rate target surprises on stock prices

The estimates in Table 2 are of (1) using three different measures of interest rate surprises. The first row (Model A) contains estimates of the impact on stock values of target surprises, based on the separation of unexpected and expected target changes using survey data. It can be seen that unexpected interest rate changes generate a significant announcement day reaction in the stock market. In particular, estimates of β_0 suggest that a 1% surprise in the fed funds target results in a stock price reaction of almost 2.5%. These findings are qualitatively consistent with previous work in the area (Thorbecke (1997); Thorbecke and Alami (1994); Chen *et al.* (1999); Smirlock and Yawitz (1985)). The restriction that the lag of ΔXU in the mean equation (β_1) is statistically insignificant cannot be rejected, suggesting that the stock price reaction to the surprise is completed on the announcement day.

I present new evidence concerning the impact of target change surprises on stock market volatility. Likelihood ratio tests reject the restriction that the lag of ΔXU in the volatility equation (ω_1) is insignificant. Estimates of ω_0 and ω_1 suggest that volatility increases on the announcement day, and then reverts to pre-surprise levels on the day after the announcement. This finding is consistent with the idea that interest rate surprises increase volatility initially, but that the information in such news is quickly assimilated into prices.

Alternative measures of the dispersion of the survey forecasts, namely the range between the maximum and minimum survey response, the range between the 75th and 25th percentile response, and the survey standard deviation, were included as additional

is not necessary to restrict parameter values to avoid negative variances.

regressors in (1). In each case, the measure of dispersion was statistically insignificant in both the conditional mean and volatility equations.

In the second row of Table 2 (Model B), the estimates are based on the separation of unexpected and expected changes in the funds rate target using changes in the 3-month T-bill yield. While the volatility estimates are qualitatively similar to those reported in the first row, the measured announcement day effect on the conditional mean of stock price changes is smaller than when using survey-based surprises. The striking difference here, however, is that the lag of ΔXU (β_1) is significant, suggesting that the stock price reaction to this measure of surprise is not completed on the announcement day. This could be attributed to the fact that changes in the T-bill yield do not measure market expectations about target changes as well as surveys do.

By way of comparison, estimates from using the entire target change as the measure of target surprises as in Bonser-Neal *et al.* (1998) and Thornton (1998) are presented in the third row of Table 2 (Model C). While the findings are qualitatively similar to those reported in the first two rows, the estimates of β_0 , ω_0 and ω_1 are again much smaller compared to those in the first row (i.e. where target surprises are measured with expectations data). This is supportive of the notion behind the efficient markets hypothesis that stock prices react primarily to news. By clubbing together the expected and unexpected components of the target change, we fail to capture the full stock market response to the interest rate surprise.

The estimates for volatility persistence/clustering (γ) and the leverage effect (ϕ, δ) are consistently significant indicative of the fact that the EGARCH model suitably accommodates those features of the data. Model diagnostics, available on request, are based on the standardized residuals (z). The residuals are *i.i.d.* - they are linearly and nonlinearly

independent. Also, χ^2 -tests reject the hypothesis that the estimated degrees of freedom parameter, ν , is equal to 2, suggesting that the residuals are conditionally non-normally distributed, and that departures from normality in the raw data cannot be attributed solely to temporal first and second moment dependencies.

***** Insert Table 2*****

4.2. Change in Disclosure policy and the impact of target surprises on stock prices

As previously noted, the Fed altered its disclosure policy with respect to target changes at the February 1994 FOMC meeting. To examine the impact of the change in the Fed's disclosure policy, the following model is estimated:

$$\Delta P_t = \alpha + \sum_{i=0}^1 B_i (1 - D_t) \Delta XU_{t-i} + \sum_{i=0}^1 \beta_i D_t \Delta XU_{t-i} + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 W_i (1 - D_t) |\Delta XU_{t-i}| + \sum_{i=0}^1 \omega_i D_t |\Delta XU_{t-i}| + \gamma \ln(h_{t-1}^2) + \phi (|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots (2)$$

where, D_t is a binary dummy variable that takes a value of one when target surprises occurred in the new (immediate) disclosure period (post-1993), and zero otherwise. The B and W coefficients measure the stock price response to interest rate surprises from 1988 through 1993 (i.e. in the old, delayed disclosure period), whereas the β and ω coefficients measure the stock price response to interest rate surprises from 1994 through January 31, 2001 (i.e. in the new, immediate disclosure period).

Table 3 contains only estimates of the parameters of interest, namely the B 's, β 's, W 's and ω 's. The constants and EGARCH terms (γ , ϕ , δ) were very similar to those reported in Table 2, and were suppressed for purposes of clarity. The estimates of (2) provide ambiguous insights into how interest rate surprises have impacted mean changes in

stock prices in the two disclosure regimes. Surprises, measured using survey data (Model A), appear to have impacted stock prices in both disclosure periods. However, surprises, measured using changes in the T-bill yield (Model B) and the entire target change (Model C), appear to have had no impact on stock price changes in the immediate disclosure era relative to the delayed disclosure regime. There is some evidence that the longer response time observed in Table 2 for such surprises (i.e. significant lag coefficient of ΔXU in the mean equation) is driven by target changes in the pre-1994 delayed disclosure era, consistent with the idea that rate changes in this period might have taken longer to decipher.

The volatility estimates of (2) in Table 3 unambiguously suggest that interest rate surprises in the immediate disclosure era have had a much more significant impact on stock market volatility, relative to surprises in the delayed disclosure era. In fact, while stock market volatility does not appear to have been significantly affected by target changes prior to 1994, volatility in the immediate disclosure period has tended to increase significantly on the announcement day, and then revert to pre-surprise levels on the day after the announcement. The implication of this finding is that any concerns that the Fed might have had about the disquieting effect of promptly disclosing target changes are probably misplaced. While volatility picks up on the announcement day (as might be expected when any news arrives), it does not persist and reverts to pre-surprise levels on the day after the target change.

***** Insert Table 3 *****

4.3. Impact of positive and negative target surprises on stock prices

Estimates of (1) imply a symmetric impact of positive and negative surprises on stock values. However, there is evidence that stock prices respond asymmetrically to good

and bad news (Koutmos, 1998, 1999). As previously noted, positive (negative) surprises arise either when the Fed raised rates more (less) than expected or lowered rates less (more) than expected. Consequently, positive surprises could be construed as “bad” news and negative surprises could be viewed as “good” news for stock prices. In (3) below, interest rate surprises are partitioned into positive and negative surprises to test for asymmetric reactions of stock prices following these announcements.

$$\Delta P_t = \alpha + \sum_{i=0}^1 \beta_{POS,i} |\Delta XU_{POS,t-i}| + \sum_{i=0}^1 \beta_{NEG,i} |\Delta XU_{NEG,t-i}| + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 \omega_{POS,i} |\Delta XU_{POS,t-i}| + \sum_{i=0}^1 \omega_{NEG,i} |\Delta XU_{NEG,t-i}| + \gamma \ln(h_{t-1}^2) + \phi(|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots (3)$$

The estimates of (3) are contained in Table 4. The hypothesis that both types of surprises have a symmetric impact on stock values is easily rejected. In fact, only negative surprises (good news) have impacted stock prices, as measured by $\beta_{NEG,0}$, while positive surprises (bad news) have not had a statistically significant effect on mean changes in stock prices.^{7 8} Moreover, positive surprises ($\omega_{POS,0}$) have a greater impact on stock market volatility than negative surprises, consistent with the idea that bad news increases volatility more than good news. The lags of the positive surprise variable in the volatility equation are significant in all three models, suggesting that the volatility reversal noted earlier is driven by positive surprises. In sum, the results suggest that while good news has a significant

⁷ Several explanations of this result are forthcoming. One, suggested by Koutmos (1998, 1999) and Lobo (2000), is that stock market participants discount bad news more vigorously and more quickly (perhaps, in anticipation of or ahead of the arrival of the news) thereby reducing the observed impact of the news when it does arrive. Another possibility relates to the fact that stock market participants perceive the Fed to be a preemptive and effective inflation fighter (Lobo, 2001). Consequently, increases in the target are greeted with a non-negative reaction, on average.

⁸ The lags of negative surprises are significant in Models B and C in line with the discussion regarding Tables 1 and 2, making conclusions about the speed of adjustment to such surprises ambiguous.

effect on the conditional mean of stock price changes, bad news has a significant impact on the conditional variance of stock price changes.

***** Insert Table 4 *****

4.4. Disclosure policy versus type of surprise: which matters more?

The conclusions from the previous two subsections, namely that disclosure policy ambiguously affected the conditional mean and unambiguously affected the conditional variance of stock prices, while different types (positive/negative) of interest rate surprises affected stock prices differently, lead logically to a test for asymmetric stock price reactions across disclosure regimes. To do so, the following model is estimated:

$$\begin{aligned} \Delta P_t &= \alpha + \sum_{j=1}^2 \sum_{i=0}^1 \beta_{ji} (1 - D_t) |\Delta XU_{j,t-i}| + \sum_{j=1}^2 \sum_{i=0}^1 \beta_{ji} D_t |\Delta XU_{j,t-i}| + \varepsilon_t \\ \ln(h_t^2) &= \theta + \sum_{j=1}^2 \sum_{i=0}^1 \omega_{ji} (1 - D_t) |\Delta XU_{j,t-i}| + \sum_{j=1}^2 \sum_{i=0}^1 \omega_{ji} D_t |\Delta XU_{j,t-i}| + \gamma \ln(h_{t-1}^2) \\ &+ \phi(|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots (4) \end{aligned}$$

where, D_t is a dummy variable that takes a value one in the immediate disclosure period from 1/1/94 through 2/2/01, and zero everywhere else. The j -subscripts index the type of shock, with $j=1$ being positive surprises and $j=2$ being negative surprises. The reader is cautioned that the small samples of positive and negative surprises in certain cases result in some loss of precision in the estimations.⁹ Nonetheless, the estimates are quite informative when viewed across the different measures of surprises used.

⁹ In the delayed disclosure period, there were 12 increases and 26 cuts in the funds rate target. Positive and negative surprises in this period based on survey data numbered 8 and 17, respectively. The numbers of positive and negative surprises based on changes in the T-bill yield were 14 and 24, respectively. In the immediate disclosure period, there were 14 increases and 8 cuts in the funds rate target. Based on survey data, there were 5 and 4 positive and negative surprises, respectively, in this period. Based on changes in the T-bill yield, there were 11 positive and negative surprises each.

The estimates of (4), which are reported in Table 5, reveal that the impact of interest rate surprises on the conditional mean were driven by the sign or type of the surprise, and not the disclosure policy adopted by the Fed. In particular, negative surprises increased stock prices in both disclosure regimes. This result, which is robust across all three measures of surprises, helps resolve the ambiguity with respect to estimates of the conditional mean in Table 3.

However, the impact of target change surprises on the conditional variance of stock prices appears to have been driven by the Fed's disclosure policy. In particular, stock market volatility was affected by positive surprises only in the immediate disclosure regime. Again, this result is robust across all three measures of surprises. The overall conclusion then is that the type of interest rate surprise is a more important influence on mean changes in stock prices regardless of the manner by which market participants gather this information, while the nature of disclosure is a more important factor affecting stock market volatility.

***** Insert Table 5 *****

5. Conclusion

This paper sought to examine the impact of unanticipated changes in the federal funds rate target from January 1988 to January 2001 on the conditional mean and variance of stock prices. The empirical analysis utilized three different measures of surprises: two techniques to separate expected and unexpected changes in the funds rate target, using survey data and changes in the 3-month T-bill yield, and the entire target change.

Consistent with much of the general news literature, this study finds that interest rate surprises have an announcement day effect on stock values. Moreover, surprises that are

constructed from survey responses yield more precise estimates of the impact of target changes on stock prices. Alternative measures of surprises bring some ambiguity to conclusions regarding the speed with which stock prices adjust to the interest rate news.

This study provides new evidence pertaining to the impact of interest rate surprises on stock market volatility. In particular, such news increases volatility on the event day (as might be expected of any unanticipated event), but then reverts to pre-surprise levels on the day after the interest rate change. Moreover, this volatility pattern is only associated with surprises in the immediate disclosure period beginning in February 1994. One implication of this finding is that Fed concerns about immediate disclosure causing persistent and heightened stock market volatility might be misplaced.

Interestingly, the analysis shows that positive and negative surprises have an asymmetric effect on the mean and volatility of stock prices. In particular, negative target surprises (good news) impacted the conditional mean of stock prices, while positive surprises (bad news) impacted the conditional variance of stock prices in a statistically significant manner. A test of these asymmetric effects across disclosure regimes revealed that while the type of interest rate surprise influenced mean changes in stock prices, the nature of disclosure was a more important factor affecting stock market volatility.

Several useful extensions of this research are forthcoming. This and other studies have shown that monetary policy has a significant impact on stock values. The issues of how and why such policy actions affect stock prices need to be more directly addressed. Perhaps, an analysis of how expectations regarding interest rate changes evolve could shed light on trader behavior and micro-market dynamics and on the issue of monetary transmission mechanisms to stock prices. Additionally, since January 2000, the FOMC

began the practice of publicly announcing any immediate change in the stance of policy (bias), as well as the committee's assessment of the balance of risks between heightened inflation pressure and economic weakness over the foreseeable future (Thornton and Wheelock, 2000). Additional research into how such changes in disclosure policy impact asset prices is warranted, perhaps when more data becomes available. A fruitful area of related research could address the issue of the spillover effects of U.S. interest rate shocks on foreign markets.

Appendix:
Changes in the Federal Funds Rate Target

Target changes and dates through to 1989 are from Bonser-Neal *et al.* (1998). The remaining target changes and dates are from the Federal Reserve Bank of New York. FFRT is the Fed Funds Rate Target. DW is day of the week. $\Delta T3m$ yield is the change in the 3-month T-Bill yield from the day after the previous target change to the day before the current target change. # Survey dates are coincident with target change dates. Bold are inter-meeting target changes since February 1994.

Target Change Date	DW	Level of FFRT (%)	Change in FFRT (%)	$\Delta T3m$ Yield (%)	Target Change Date	DW	Level of FFRT (%)	Change in FFRT (%)	$\Delta T3m$ Yield (%)
1/28/88	TH	6.625	-0.125	+0.160	9/13/91#	F	5.25	-0.25	-0.190
2/11/88	TH	6.50	-0.125	-0.030	10/31/91	TH	5.00	-0.25	-0.340
3/30/88	W	6.75	+0.25	-0.010	11/6/91	W	4.75	-0.25	+0.010
5/9/88	M	7.00	+0.25	+0.580	12/6/91#	F	4.50	-0.25	-0.320
5/25/88	W	7.25	+0.25	-0.030	12/20/91#	F	4.00	-0.50	-0.110
6/22/88	W	7.375	+0.125	+0.140	4/9/92	TH	3.75	-0.25	+0.110
7/1/88#	F	7.50	+0.125	+0.040	7/2/92#	TH	3.25	-0.50	-0.100
8/9/88	T	8.125	+0.625	+0.290	9/4/92#	F	3.00	-0.25	-0.100
10/20/88	TH	8.25	+0.125	+0.440	2/4/94#	F	3.25	+0.25	+0.210
11/22/88	T	8.50	+0.25	+0.550	3/22/94	T	3.50	+0.25	+0.300
12/15/88	TH	8.75	+0.25	+0.110	4/18/94	M	3.75	+0.25	+0.130
1/5/89	TH	9.00	+0.25	+0.090	5/17/94	T	4.25	+0.50	+0.410
2/14/89	T	9.25	+0.25	+0.260	8/16/94	T	4.75	+0.50	+0.260
2/24/89#	F	9.75	+0.50	+0.120	11/15/94	T	5.50	+0.75	+0.710
6/6/89	T	9.50	-0.25	-0.420	2/1/95	W	6.00	+0.50	+0.460
7/7/89#	F	9.25	-0.25	-0.370	7/6/95	TH	5.75	-0.25	-0.340
7/27/89	TH	9.00	-0.25	+0.270	12/19/95	T	5.50	-0.25	-0.180
10/19/89	TH	8.75	-0.25	-0.360	1/31/96	W	5.25	-0.25	-0.010
11/6/89	M	8.50	-0.25	+0.290	3/25/97	T	5.50	+0.25	+0.360
12/20/89	W	8.25	-0.25	-0.080	9/29/98	T	5.25	-0.25	-0.850
7/13/90#	F	8.00	-0.25	+0.120	10/15/98	TH	5.00	-0.25	-0.330
10/29/90	M	7.75	-0.25	-0.480	11/17/98	T	4.75	-0.25	+0.850
11/14/90	W	7.50	-0.25	-0.100	6/30/99	W	5.00	+0.25	+0.370
12/7/90#	F	7.25	-0.25	-0.090	8/24/99	T	5.25	+0.25	+0.230
12/19/90	W	7.00	-0.25	-0.130	11/16/99	T	5.50	+0.25	+0.330
1/9/91	T	6.75	-0.25	-0.110	2/2/00	W	5.75	+0.25	+0.450
2/1/91#	F	6.25	-0.50	-0.060	3/21/00	T	6.00	+0.25	+0.280
3/8/91#	F	6.00	-0.25	+0.090	5/16/00	T	6.50	+0.50	+0.200
4/30/91	T	5.75	-0.25	-0.300	1/3/01	W	6.00	-0.50	-0.190
8/6/91	T	5.50	-0.25	-0.040	1/31/01	W	5.50	-0.50	-0.340

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Table 1

Descriptive statistics on daily percentage changes in the S&P 500 index: January 1, 1988 to February 2, 2001 (N=3416)

Daily changes (ΔP_t) were computed as percentage changes in the closing values of the S&P 500 index from day $t-1$ to day t . The p-values are for the test that the estimates are no different from zero. $LB(n)$ and $LB^2(n)$ are the Ljung-Box statistics for ΔP_t and ΔP_t^2 , respectively, distributed Π^2 with n degrees of freedom, where n is the number of lags.

Measure	Estimate	p-value
Mean	0.0548	0.0009
Std. Deviation	0.9508	
Skewness	-0.3309	0.0000
Kurtosis	5.2618	0.0000
LB(10)	35.8214	0.0000
LB ² (10)	344.0039	0.0000

Table 2
The impact of federal funds rate target surprises on stock prices

Parameter estimates are from the following model, where ΔP_t is the percentage change in the closing values of the S&P 500 index, and ΔXU are interest rate surprises. The models are distinguished by the measure of interest rate surprise (XU) used, as follows:

Model A: ΔXU are the unexpected target changes computed by subtracting from the actual target change the expected change in the target, measured using survey median data

Model B: ΔXU are the unexpected target changes computed by subtracting from the actual target change the difference between the 3-month T-Bill yield on the day before the target change and the yield on the day after the previous target change.

Model C: ΔXU are the entire target change

Standard errors are in parentheses. LRS_1 and LRS_2 are likelihood ratio test statistics, each distributed χ^2 with 1 degree of freedom.

$$\Delta P_t = \alpha + \sum_{i=0}^1 \beta_i \Delta XU_{t-i} + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 \omega_i |\Delta XU_{t-i}| + \gamma \ln(h_{t-1}^2) + \phi (|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots \dots \dots (1)$$

Model	Parameter Estimates									LRS ₁ Null: β ₁ =0	LRS ₂ Null: ω ₁ =0
	α x 100	β ₀	β ₁	θ x 100	ω ₀	ω ₁	γ	φ	δ		
A.	4.37 (1.31) ***	-2.46 (0.75) ***	-0.26 (0.61)	0.16 (0.09) *	2.66 (1.21) **	-3.12 (1.18) ***	0.99 (0.01) ***	0.05 (0.01) ***	-0.55 (0.13) ***	0.23	11.85 ***
B.	4.36 (1.30) ***	-1.03 (0.59) *	-1.13 (0.43) ***	0.08 (0.11)	1.32 (0.82) *	-1.39 (0.81) *	0.99 (0.01) ***	0.06 (0.01) ***	-0.52 (0.13) ***	6.37 **	3.87 **
C.	4.50 (1.30) ***	-0.80 (0.44) *	-0.28 (0.28)	0.18 (0.11) *	1.53 (0.64) **	-1.73 (0.63) ***	0.99 (0.01) ***	0.05 (0.01) ***	-0.53 (0.13) ***	0.85	10.33 ***

*** indicates statistical significance at the 0.01 level
 ** indicates statistical significance at the 0.05 level
 * indicates statistical significance at the 0.10 level

Table 3

Disclosure policy and the impact of federal funds rate target surprises on stock prices

The parameter estimates are for the model described below. See also notes to Table 2. D_t is a dummy variable that takes a value 1 in the period from 1/1/94 through 2/2/01, and zero everywhere else. This break in the sample is motivated by the change in the FOMC's disclosure policy after 1993. Until its February 1994 meeting, the FOMC followed the practice of issuing a policy directive several weeks after the meeting in which a target change had been approved. Since February 1994, however, the FOMC has publicly announced changes in current monetary policy immediately upon making them. The sub-sample estimates are designed to capture the differential impact, if any, of target surprises on stock prices in the two disclosure regimes. The estimates of the B 's and W 's are for the sub-sample from 1988 through 1993, whereas estimates of the β 's and ω 's are for the sub-sample from 1994 through 2001. Standard errors are in parentheses. LRS_1 and LRS_2 are likelihood ratio test statistics, each distributed χ^2 with 2 degrees of freedom.

$$\Delta P_t = \alpha + \sum_{i=0}^1 B_i (1 - D_t) \Delta XU_{t-i} + \sum_{i=0}^1 \beta_i D_t \Delta XU_{t-i} + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 W_i (1 - D_t) |\Delta XU_{t-i}| + \sum_{i=0}^1 \omega_i D_t |\Delta XU_{t-i}| + \gamma \ln(h_{t-1}^2) + \phi(|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots \dots \dots (2)$$

The models are distinguished by the measure of interest rate surprise (XU) used, as follows:

Model A: ΔXU are the unexpected target changes computed by subtracting from the actual target change the expected change in the target, measured using survey median data; Model B: ΔXU are the unexpected target changes computed by subtracting from the actual target change the difference between the 3-month T-Bill yield on the day before the target change and the yield on the day after the previous target change; Model C: ΔXU are the entire target change.

Model	Select Parameter Estimates								LRS ₁ (H ₀ : B ₁ =β ₁ =0)	LRS ₂ (H ₀ : W ₁ =ω ₁ =0)
	B ₀	B ₁	β ₀	β ₁	W ₀	W ₁	ω ₀	ω ₁		
A	-1.64 (0.90) *	-1.37 (0.96)	-2.78 (1.47) **	0.99 (0.72)	0.07 (1.75)	-0.33 (1.74)	4.55 (2.53) *	-6.05 (2.57) **	4.59	24.84 ***
B	-1.00 (0.58) *	-1.17 (0.49) **	-1.66 (1.46)	-0.70 (1.11)	0.80 (1.18)	-0.89 (1.17)	2.95 (1.26) **	-2.96 (1.25) **	6.69 **	8.52 ***
C	-0.89 (0.44) **	-1.09 (0.40) ***	-1.22 (0.90)	0.47 (0.54)	0.12 (1.10)	-0.31 (1.07)	2.77 (1.20) **	-3.22 (1.22) ***	7.81 ***	93.21 ***

*** indicates statistical significance at the 0.01 level; ** indicates statistical significance at the 0.05 level; * indicates statistical significance at the 0.10 level

Table 4

The asymmetric impact of positive and negative target surprises on stock prices

The parameter estimates are for the model described below, designed to test for asymmetric stock price responses to positive and negative surprises. ΔXU_{POS} are positive target change surprises or “bad” news, which arise either when the Fed raised rates more than expected or lowered rates less than expected. ΔXU_{NEG} are negative target change surprises or “good” news, which arise either when the Fed raised rates less than expected or lowered rates more than expected. Standard errors are in parentheses. LRS_1 and LRS_2 are likelihood ratio test statistics, each distributed χ^2 with 2 degrees of freedom.

$$\Delta P_t = \alpha + \sum_{i=0}^1 \beta_{POS,i} |\Delta XU_{POS,t-i}| + \sum_{i=0}^1 \beta_{NEG,i} |\Delta XU_{NEG,t-i}| + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{i=0}^1 \omega_{POS,i} |\Delta XU_{POS,t-i}| + \sum_{i=0}^1 \omega_{NEG,i} |\Delta XU_{NEG,t-i}| + \gamma \ln(h_{t-1}^2) + \phi(|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots (3)$$

The models are distinguished by the measure of interest rate surprise (ΔXU) used, as follows:

Model A: ΔXU are the unexpected target changes computed by subtracting from the actual target change the expected change in the target, measured using survey median data ; Model B: ΔXU are the unexpected target changes computed by subtracting from the actual target change the difference between the 3-month T-Bill yield on the day before the target change and the yield on the day after the previous target change; Model C: ΔXU are the entire target change.

Select Parameter Estimates	Model A	Model B	Model C
<u>A. Conditional Mean</u>			
$\beta_{POS,0}$	-1.03 (1.54)	-0.05 (1.20)	-0.33 (0.71)
$\beta_{POS,1}$	0.72 (0.96)	-0.30 (0.74)	0.35 (0.45)
$\beta_{NEG,0}$	3.29 (1.16) ***	1.34 (0.72) *	1.51 (0.62) **
$\beta_{NEG,1}$	0.93 (0.76)	1.24 (0.52) **	1.24 (0.46) ***
$LRS_1 (H_0): \beta_{POS,1} = \beta_{NEG,1} = 0$	2.27	7.26 ***	7.88 ***
<u>B. Conditional Variance</u>			
$\omega_{POS,0}$	4.49 (1.99) **	2.28 (1.62)	1.69 (0.85) **
$\omega_{POS,1}$	-5.48 (2.03) ***	-2.73 (1.65) *	-2.00 (0.86) **
$\omega_{NEG,0}$	1.54 (1.67)	1.24 (0.92)	1.24 (1.03)
$\omega_{NEG,1}$	-1.88 (1.64)	-1.16 (0.93)	-1.45 (1.01)
$LRS_2 (H_0): \omega_{POS,1} = \omega_{NEG,1} = 0$	15.21 ***	5.15	10.44 ***

*** indicates statistical significance at the 0.01 level

** indicates statistical significance at the 0.05 level

* indicates statistical significance at the 0.10 level

Table 5

Disclosure policy versus type of surprise: what matters more?

The parameter estimates are for the model described below, designed to test for asymmetric stock price responses to positive and negative surprises across disclosure regimes. D_t is a dummy variable that takes a value 1 in the immediate disclosure period from 1/1/94 through 2/2/01, and zero everywhere else. The j -subscripts index the type of shock, with $j=1$ being positive surprises (POS) and $j=2$ being negative surprises (NEG). Standard errors are in parentheses. LRS_1 and LRS_2 are likelihood ratio test statistics distributed χ^2 with 4 degrees of freedom, for the test that the lags in the conditional mean and variance, respectively, are collectively equal to zero.

$$\Delta P_t = \alpha + \sum_{j=1}^2 \sum_{i=0}^1 \beta_{ji} (1 - D_t) |\Delta XU_{j,t-i}| + \sum_{j=1}^2 \sum_{i=0}^1 \beta_{ji} D_t |\Delta XU_{j,t-i}| + \varepsilon_t$$

$$\ln(h_t^2) = \theta + \sum_{j=1}^2 \sum_{i=0}^1 \omega_{ji} (1 - D_t) |\Delta XU_{j,t-i}| + \sum_{j=1}^2 \sum_{i=0}^1 \omega_{ji} D_t |\Delta XU_{j,t-i}| + \gamma \ln(h_{t-1}^2) + \phi (|z_{t-1}| - E|z_{t-1}|) + \delta z_{t-1} \dots (4)$$

The models are distinguished by the measure of interest rate surprise (ΔXU) used. See Table 4 for details.

Select Parameter Estimates	Model A	Model B	Model C
A. Conditional Mean			
	<u>Delayed Disclosure Period</u>		
$\beta_{POS,0}$	-0.16 (2.56)	-2.28 (0.95) **	-1.19 (0.90)
$\beta_{POS,1}$	0.14 (1.63)	0.60 (1.33)	-0.52 (0.88)
$\beta_{NEG,0}$	1.78 (0.99) *	0.82 (0.67)	0.16 (0.58)
$\beta_{NEG,1}$	1.74 (1.17)	1.58 (0.52) ***	1.58 (0.49) ***
	<u>Immediate Disclosure Period</u>		
$\beta_{POS,0}$	-1.42 (2.58)	2.01 (2.85)	-1.86 (1.77)
$\beta_{POS,1}$	1.18 (1.38)	-1.80 (0.64) ***	0.54 (0.65)
$\beta_{NEG,0}$	6.15 (1.89) ***	4.76 (2.86) *	2.25 (0.78) ***
$\beta_{NEG,1}$	-0.81 (0.94)	0.27 (3.27)	0.27 (0.82)
LRS_1	5.46	11.18 **	11.66 **
B. Conditional Variance			
	<u>Delayed Disclosure Period</u>		
$\omega_{POS,0}$	1.06 (3.79)	-0.72 (2.75)	-1.42 (2.13)
$\omega_{POS,1}$	-1.64 (3.72)	0.77 (2.69)	1.18 (2.10)
$\omega_{NEG,0}$	-0.06 (2.21)	0.81 (1.38)	0.85 (1.05)
$\omega_{NEG,1}$	-0.16 (2.19)	-1.01 (1.37)	-0.98 (1.04)
	<u>Immediate Disclosure Period</u>		
$\omega_{POS,0}$	5.73 (4.08)	5.66 (2.26) **	4.12 (2.40) *
$\omega_{POS,1}$	-7.45 (4.19) *	-6.90 (2.56) ***	-5.03 (2.48) **
$\omega_{NEG,0}$	0.89 (7.27)	2.85 (4.68)	1.55 (1.36)
$\omega_{NEG,1}$	-2.32 (7.17)	-2.22 (4.49)	-1.59 (1.38)
LRS_2	17.72 ***	13.16 **	145.39 ***

***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.