
CENTRAL BANK COMMUNICATIONS AND EQUITY ETFs

TAO WANG
JIAN YANG*
JINGTAO WU

This article examines effects of monetary policy surprises on returns, volatilities, trading volumes, and bid–ask spread of two equity ETFs, the S&P 500 SPY fund and the S&P 400 MDY fund. The policy surprises are measured by both surprises in the federal funds rate target changes and surprises in the future direction of the Federal Reserve monetary policy. The results show that there is an overreaction of the SPY to the federal funds rate target surprise in the first 5 minutes' trading and that both the SPY and the MDY returns, volatilities, trading volumes, and bid–ask spread react more strongly to surprise cuts than to surprise increases in the federal funds rate target. Quantitatively, after 45 minutes, an unanticipated

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*Correspondence author, Department of Accounting, Finance & MIS, Prairie View A&M University, Prairie View, Texas 77446; e-mail: jiyang@pvamu.edu

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- *Tao Wang is an Assistant Professor of Economics in the Department of Economics at Queens College and the Graduate School of the City University of New York, New York.*
 - *Jian Yang is an Associate Professor of Finance in the Department of Accounting, Finance & MIS at Prairie View A&M University, Texas.*
 - *Jingtao Wu is a Ph.D. candidate in the Department of Economics at Iowa State University in Ames, Iowa.*

25-basis-point cut in the federal funds rate target is associated with an increase of 1.2 and 1.6% in the SPY and the MDY, respectively, while an unanticipated 25-basis-point decline (or rise) in the four-quarter-ahead eurodollar futures rate is associated with an increase (or decrease) of 0.71 and 0.40% in the SPY and the MDY, respectively. Further evidence also suggests that the market reacts more strongly to surprises in the future direction of monetary policy during the monetary tightening period and that the impact of monetary policy surprises depends on their sizes. © 2006 Wiley Periodicals, Inc. *Jrl Fut Mark* 26:959–995, 2006

INTRODUCTION

The role of monetary policy in explaining stock returns has been extensively investigated. However, earlier studies typically use monthly stock market index data to study the link between monetary policy and the stock market (e.g., Thorbecke, 1997). The drawbacks of using monthly data to estimate the monetary policy impact on the stock market include the endogeneity problem and the omitted variable bias (Bernanke & Kuttner, 2005). Even at the daily frequency, Rudebusch (1998) notes that simultaneity bias can still be a potential problem because the U.S. Federal Open Market Committee (FOMC) for a time often changed its federal funds target hours after the unemployment report release by the Bureau of Labor Statistics. To overcome these problems, recent studies have used high-frequency intraday (or daily) data to study the effect of monetary policy announcements on asset prices, which typically use the federal funds rate alone as the U.S. monetary policy indicator (e.g., Anderson et al., 2003; Bernanke & Kuttner, 2005). Such practice is well supported by recent evidence that unanticipated changes in the federal funds rate affect the stock market, whereas anticipated changes in the federal funds rate have little effect (e.g., Bernanke & Kuttner, 2005; Rigobon & Sack, 2002).

Most recently, however, researchers tend to look beyond the federal funds rate changes alone as the primary monetary policy indicator. This is motivated by an important fact that the U.S. Fed monetary policy decision making has moved significantly in the direction of greater transparency over the past decade, which should help communicate with market participants and shape investor expectations better. In particular, since February 1994, the FOMC (Federal Open Market Committee) began releasing statements that accompanied changes in the federal funds rate target. These statements explained the rationale for the policy action. Later on, the FOMC statements also provided either explicit assessment of the risk going forward or future policy tilt. Therefore, the

FOMC statements may provide additional information of the (potential) stance of monetary policy beyond the information on the federal funds rate target.

As a result, there is an emerging literature on whether the so-called nonstandard monetary policies such as FOMC statements can help shape the expectations of private investors. Specifically, examining the impact of FOMC statements on the term structure of interest rates, Bernanke, Reinhart, and Sack (2004) find that clear communication from the FOMC statements can help increase the near-term predictability of FOMC federal funds rate decisions at future dates. Gurkaynak et al. (2005) decompose the information from the FOMC meetings into two factors, the target factor (i.e., the surprises in the federal funds rate target) and the path factor (i.e., the surprises in the future direction of the federal reserve monetary policy independent of changes in the current funds rate target). They document that both factors have important but different effects on Treasury Bond yields, whereas only surprises in the federal funds target have impact on the S&P 500 index. Similarly, Kohn and Sack (2003) also show that central bank statements can affect market interest rates.

Another strand of this literature has examined the effects of monetary policy on firms of different sizes with the use of monthly or quarterly data. For example, Gertler and Gilchrist (1994) analyze the response of small versus large manufacturing firms to monetary policy. They find that small firms account for a significantly disproportionate share of the manufacturing decline that follows the tightening of monetary policy, which plays a surprisingly prominent role in the slowdown of inventory demand. Kashyap and Stein (2000) examine the monetary transmission mechanism with the use of quarterly observations of every insured U.S. commercial bank from 1976 to 1993. They find that the impact of monetary policy on lending is stronger for banks with less liquid balance sheets (i.e., banks with lower ratios of securities to assets). Moreover, this pattern is largely attributable to the smaller banks. Both findings are interpreted as consistent with the credit-channel explanation of the monetary transmission mechanism.

This article uses high-frequency intraday equity data to examine the effects of central bank monetary policy announcements on the returns and trading of two exchange-traded funds (ETF): SPY, the ETF fund that mimics the S&P 500 large-cap stocks, and MDY, the ETF fund that mimics the S&P 400 midcap stocks. The present study differs from previous research significantly in three aspects. First, this article addresses the impact of monetary policy news on equity ETFs by exploring the

effects not only from the unexpected changes in the federal funds rate target, but also from unexpected changes in the Federal Reserve future monetary policy as implied in the FOMC statements or rate-change decisions. A very few recent works (e.g., Bernanke et al., 2004; Gurkaynak et al., 2005) have examined cash stock market indexes but not index-linked financial instruments such as equity ETFs. Equity ETFs are different from broad stock-market indexes, as the former are regularly and continuously traded, whereas the latter are not directly tradable. In this context, ETFs would be free from the nonsynchronous trading problem of stock-market indexes and the intraday impact on ETFs is more relevant to real-time trading than that on cash market indexes. Also, ETFs are traded like closed-end mutual funds and have a low transaction cost, which may suggest more efficient processing of the information (Hasbrouck, 2003).¹ The use of ETF data leads to new findings on the impact of monetary policy news on asset prices. Within the first 5 minutes, an unanticipated 25-basis-point cut in the federal funds rate target is associated with about 1.8% increase in the SPY. By contrast, Gurkaynak et al. (2005) only find about 1% increase in the S&P 500 cash index with the use of 30-minute returns data. More importantly, the path factor puzzlingly has a statistically insignificant effect on the S&P 500 cash index in Gurkaynak et al. (2005), whereas this study reports generally favorable evidence. Furthermore, unlike Gurkaynak et al. (2005) and many other studies that focus on returns of single broad market index (the S&P 500 or the CRSP value-weighted index) (e.g., Bernanke & Kuttner, 2005; Kuttner, 2001), this article examines different market capitalization ETFs.² This would enable one to test whether monetary policy affects firms of different sizes differently, which is not addressed in Gurkaynak et al. (2005). Also as an extension of Gertler and Gilchrist (1994) and Kashyap and Stein (2000), the use of high-frequency intraday data can avoid the endogeneity problem as well as the omitted variable bias. With a small window of 5 minutes after the FOMC announcements, it can be assured that the FOMC decisions are not influenced by the financial market or other macroeconomic news.

Second, this article examines nonlinear response of equity ETFs to monetary policy. Prior studies mostly emphasize a linear relationship

¹Another important advantage of ETF data over cash stock market indexes lies in that they also contain information on trading volume and bid–ask spread, which is of interest in this study.

²As discussed below, this study further substantially differs from Gurkaynak et al. (2005) in that its focus is on nonlinear (instead of linear) response to monetary policy, and it examines the applicability of the two-factor model to price volatility, the trading volume, and bid–ask spread rather than returns alone.

between monetary policy and the stock market cash indexes. As a notable exception, Bernanke and Kuttner (2005) employ a one-factor model and examine whether the magnitude of the market's response depends on the sign of the Federal funds rate target surprise or the direction of the rate movement. This study not only examines the potential asymmetries associated with the sign of the surprises and the direction of the rate movements, but also the size of the surprises as well. Furthermore, all the potential nonlinear effects are studied within the context of the two-factor model of Gurkaynak et al. (2005), which has not yet been addressed in the literature.

Third, prior literature on the impact of monetary policy has been largely limited to the analysis of asset prices or volatility. This study extends the analysis by including trading volume and quoted bid–ask spread in order to examine market behaviors around the FOMC announcements more thoroughly. Although research concerning these trading activity variables in the U.S. treasury market around macroeconomic news announcements has yielded insights into market adjustment processes (e.g., Balduzzi et al., 2001; Fleming & Remolona, 1999), few studies have examined the effects of monetary policy surprises on equity-related trading volume and quoted bid–ask spread, and none has examined potential asymmetric effects of monetary policy surprises on these trading activity variables of financial markets. In particular, it is documented that strong and persistent reactions of SPY and (to a lesser degree) MDY trading volumes to the path factor, whereas no such strong and persistent pattern exists for the return and volatility response.³ This finding provides additional indications of information processing by traders. On the other hand, in sharp contrast with returns, volatility, and particularly trading volume, the bid–ask spreads of ETF trading generally do not respond to the path factor throughout the 45-minute period after the FOMC rate decisions.

The rest of the article is as follows. The next section describes the data used. Then the baseline analysis of the effect of central bank communications on returns, volatilities, volumes, and bid–ask spread of the two ETFs. The asymmetric effects of monetary policy on returns and volatilities are presented, and the asymmetric effects of monetary policy on trading volumes and bid–ask spreads are analyzed. The last section concludes.

³As volume of trade reflects investors' activity, whereas prices reflect investors' beliefs (Bamber, 1986), price changes could happen without much trading (Fleming and Remolona, 1999), or trading activity could increase without much price changes.

DATA AND RESEARCH DESIGN

ETF Data

Two ETFs are used in this analysis. The first one is the ETF for the large cap index, the Standard and Poor's Depositary Receipts (SPDR) traded under the ticker name of SPY. The trust was created on January 22, 1993, to provide investors an investment vehicle that mimics the S&P 500 index. The size of the fund was about \$49 billion in November 2005 and it is the largest ETF fund traded. The second one is the ETF for the mid-cap index. The MidCap SPDR trust (MDY) is an exchange-traded fund designed to generally correspond to the performance of the S&P MidCap 400 index. The trust was created on May 4, 1995, and the size of the fund was about \$8 billion in November 2005.⁴

For the two ETFs, the 5-minute return series are calculated based on the average of the bid and ask prices at or immediately before each 5-minute mark. The data are also collected on actual trade prices, and number of shares traded for each price for robustness check. The definitions of intraday return, volatility, volume, and bid–ask spread closely follow that in Balduzzi et al. (2001), except that the mid price of the bid and ask prices is used to calculate the returns as well as the volatility series. In the following regressions, the 5-minute return, volatility, volume, and bid–ask spread data surrounding the FOMC announcements are used to construct the dependent variables. All data series are from the NYSE TAQ database.

FOMC Statements and the Federal Funds Rate Surprises

The effects of monetary policy are studied on the two ETF funds. Most of existing literature uses the changes in the federal funds rate alone as the indicator of changes in monetary policy. To facilitate comparison, the surprise component of monetary policy is used, because changes in monetary policy that are expected by the markets should have little or no effect on asset prices. There are generally two methods in calculating the surprise component of monetary policy. One method is to use the difference between the federal funds rate target announced by the FOMC and the consensus forecasts of the federal funds rate target typically collected

⁴The iShares Russell 2000 small-cap index fund (Ticker IWM) is not included in the analysis, because the iShares ETF funds started only on May 22, 2000, which would seriously limit the sample size. For a similar reason, the Nasdaq 100 (QQQ) trust series is not included; it started on March 10, 1999.

through surveys. The advantage of this method is that data are easily collectable and it has been used by many studies on macroeconomic news announcement effects (e.g., Andersen, Bollerslev, Diebold, & Vega, 2003). The disadvantage of this method is that the consensus forecasts are still subject to potential bias and the data is typically of weekly (or at most daily) frequency, which could induce the endogeneity problem as well as the errors-in-variable problem. The second method is to take advantage of the federal funds futures that have been traded on the Chicago Board of Trade since October 1988. One method has been proposed by Kuttner (2001) that uses the daily closing prices of the federal funds futures. Basically, the unexpected component of the federal funds rate, denoted $\Delta Fundrate^U$, are calculated based on the specification from Kuttner (2001):

$$\Delta Fundrate^U = \frac{D}{D - d} \Delta Fundrate$$

where D is the total number of days of the month, d is the day of the month of the FOMC decision, and $\Delta Fundrate^U$ is the change in the futures rate on the day of the policy decision. Following Gurkaynak et al. (2005), the intraday federal funds futures data, instead of the daily changes in the futures rate, are used to calculate the unexpected federal funds rate target changes. The policy surprises are computed by taking the differences between the federal funds futures rate 10 minutes prior to the monetary policy announcements and 20 minutes after the announcements.

Following the recent literature (e.g., Bernanke et al., 2004; Gurkaynak et al., 2005; Kohn & Sack, 2003), the focus of this study is on the impact of the so-called nonstandard monetary policy, that is, the impact of policy implications implied in the FOMC statements. The FOMC has moved significantly in the direction of greater transparency over the past decade. From January 1989 to December 1993, the FOMC typically relied upon open market operations to signal shifts in monetary policy without making announcements on rate changes. Since February 1994, the FOMC began releasing statements sporadically that accompanied changes in the federal funds rate. Those statements explained the rationale for the policy action. Furthermore, at the December 1998 meeting, the FOMC decided to include more information in the statements when “it wanted to communicate to the public a major shift in its views about the balance of risks or the likely direction of future policy.” It first did so at the May 1999 FOMC meeting, when the FOMC announced a policy tilt toward tightening. In January 2000, the FOMC

announced that a statement would be released after every FOMC meeting and always include an assessment of the “balance of risks.” The balance-of-risks assessment would be linked to the FOMC’s macroeconomic objective rather than to the near-term direction of monetary policy. Particularly, the statements would indicate whether the risk for the economy over “foreseeable future” is weighted toward “economic weakness” or “heightened inflation pressures,” or the risk is balanced. This policy remained in effect until today. Therefore, the current sample period covers all FOMC statements from May 1995 to December 2004. An argument can also be made that even on the date when no FOMC statement was issued, the rate change itself could potentially affect the market’s expectation on future rate changes.

Hence, to examine the impact of monetary policy on ETF prices, this article closely follows Gurkaynak et al. (2005), who use the principal-components method to decompose the impact of monetary policy into two factors, the target factor and the path factor.⁵ After the decomposition, the target factor represents the measure of the federal funds target surprises. The target factor is closely correlated with the surprises in the federal funds rate target, with the correlation coefficient being over 95%. The path factor represents the surprises in FOMC’s possible future policy and its interpretation of economic outlook. This reflects the wording of the FOMC statements, which could contain “important information about the state of the economy of the path of monetary policy that was not expected by a substantial portion of market participants” (Bernanke et al., 2004). The two factors are transformed so that they are orthogonal to each other. To facilitate comparison between the two factors and the federal funds rate target surprises, the target factor is scaled so that “a change of 1 in the target factor corresponds to a surprise of 1 basis point in the federal funds target rate”; the path factor is scaled so that “the effect of the path factor on the four-quarter-ahead Eurodollar futures rate is exactly the same as the effect of the target factor on the four-quarter-ahead Eurodollar futures rate, about 53 basis points” (due to 100 basis points changes in the target factor). Therefore, the path factor reflects the impact of the surprises in the future direction of the interest-rate changes due to monetary policy changes independent of the current changes in federal funds rate target.⁶

⁵Bernanke et al. (2004) constructed three factors through a Choleskey decomposition: the current policy surprise, changes in year-ahead policy expectations (as measured by the change in eurodollar futures not explained by the first factor), and the change in the 5-year treasury yield not explained by the first two factors.

⁶Bernanke et al. (2004) confirm that the path factor indeed measures the expected four-quarter-ahead eurodollar future rate changes due to the monetary policy changes.

Basic Regression Design

Most studies on news announcements using high-frequency data tend to apply ordinary least-squares (OLS) estimator to serve the purpose. In this article the impact of monetary policy announcements on stocks is examined with the use of the seemingly unrelated regressions (SUR) estimator. The justification for the use of SUR is straightforward. Even though the OLS estimator would be unbiased and consistent in the high-frequency setting, the SUR estimator may be more efficient because the errors between the two ETFs are likely to be contemporaneously correlated. More importantly, the use of the SUR estimator in this study would allow for direct hypothesis tests on cross-equation restrictions (for example, whether the impacts of monetary policy on ETFs of different sizes are similar).

In general, the two basic regressions can be set up as follows:

$$y_{i,t} = \alpha_i + \beta_{i,1}\Delta Fundrate^U + \varepsilon_{it} \quad (1)$$

$$y_{i,t} = \alpha_i + \beta_{i,1}s_{FF,t} + \beta_{i,2}s_{FS,t} + \varepsilon_{it} \quad (2)$$

where i is B or S , B represents the large-cap SPY fund, S represents the mid-cap MDY fund, $s_{FF,t}$ is the target factor, and $s_{FS,t}$ is the path factor in Gurbaynak et al. (2005). The independent variable $\Delta Fundrate^U$ is the surprise in the federal funds rate target as the difference between the federal funds futures rate 10 minutes before the policy change and 20 minutes after the policy change. The two dependent variables represent either returns, volatilities, volume of trade, or the bid–ask spread for the two ETF funds around the FOMC announcements. Equation (1) examines how the surprises in the federal funds rate target affect the ETF trading. This specification is similar to most previous studies, except that SUR is used as the estimator. Equation (2) is a two-factor model, exploring the possibility that both surprises in the federal funds rate target and surprises in the future directions of interest rate changes affect the ETF trading. In the hypothesis testing under SUR, whether the impacts of monetary policy on the two ETFs are the same is examined by testing $\beta_{B,1} = \beta_{S,1}$ and $\beta_{B,2} = \beta_{S,2}$. Finally, as discussed below in more detail, whether the impacts of central bank communications are asymmetric or state dependent is also explored by further allowing for asymmetries in the above regressions.

BASELINE REGRESSION RESULTS

Because the MDY only started trading in May 1995, the sample in the present FOMC announcements includes 81 FOMC meetings and spans the period of time from May 23, 1995, to December 14, 2004. Although

the sample size is not large, it is comparable to recent related studies on macroeconomic news announcements (e.g., Andersen et al., 2003; Bernanke & Kuttner, 2005; Christie-David, Chaudhry, & Lindley, 2003). Detailed description of the data on FOMC announcements can be found at Gurkaynak et al. (2005).

The impact of monetary policy surprises is also tested with the use of Equations (1) and (2) in the baseline regressions. In the regression for the one-factor model, the 5-minute returns, volatilities, volume of trade, and the average bid–ask spread immediately after FOMC announcements are regressed on $\Delta Fundrate^U$, the federal funds rate target surprise defined in the previous section. Because the majority of FOMC announcements occur around 14:15 P.M. during the sample period, majority of $\Delta Fundrate^U$ would be the difference between the federal funds futures rates at 14:05 P.M. and 14:35 P.M.

Table I presents the basic regression results from the SUR estimation. Five-minute returns are defined as the logarithmic difference of the midpoint of the bid and ask prices immediately before or at each 5-minute point (multiplied by 1,000). The midpoints of the bid and ask instead of the transaction prices were chosen because the two ETFs, especially the MDY, are not frequently traded during the earlier years of the sample. In the returns regression from Panel A, an unanticipated 100-basis-point cut in the federal funds rate target (or the target factor), in the absence of any surprises in the accompanying FOMC statement, leads to an increase of 7.49 percent (or 7.25%) in the SPY in the one-factor model (or the two-factor model), and 6.14% (or 5.91%) increase in the MDY in the one-factor (or the two-factor) model.⁷ Because the target factor is scaled so that a change of 1 in the target factor is quantitatively the same as a one-basis-point unexpected change in the federal funds rate target, $\Delta Fundrate^U$, it is not surprising that regressions yield numerically similar coefficients for the surprises in the federal funds rate changes. In addition, both results are statistically significant at the 1% level. The result stands in contrast with some recent studies (e.g., Bernanke & Kuttner, 2005; Gurkaynak et al., 2005), which find that an unanticipated 25-basis-point cut in the federal funds rate target is associated with about a 1% increase in the cash stock-market index; thus an unanticipated 100-basis-point cut corresponds to a 4% rise in the cash stock-market index. The impact of the surprises in the federal funds

⁷This translates to that an unanticipated 25-basis-point cut in the federal funds rate target is associated with about 1.8% increase in the SPY price and 1.5% increase in the MDY price in the first 5 minutes.

rate target changes on the SPY ETF appears to be greater during the first 5 minutes.

The impact of the path factor is smaller than that of the target factor, with a one-percentage-point negative surprise to the path factor associated with an increase of 0.79% in the SPY (significant at the 10% level) and 0.04% in the MDY (insignificant at any conventional levels), respectively. Because the effect of the scaled path factor on the four-quarter-ahead eurodollar futures rate is 53 basis points, because of the 100-basis-points changes in the path factor independent of the changes

TABLE I
Baseline SUR Model Estimation^a and Hypotheses Tests

	<i>One-factor model</i>		<i>Two-factor model</i>	
	<i>S&P 500</i>	<i>S&P 400</i>	<i>S&P 500</i>	<i>S&P 400</i>
<i>Panel A: Return</i>				
β_1	-0.749 (-10.42) ^{b,***}	-0.614 (-9.63) ^{***}	-0.725 (-10.42) ^{***}	-0.591 (-9.36) ^{***}
β_2			-0.079 (-1.66) [*]	-0.004 (-0.10)
R^2	0.573	0.534	0.579	0.520
Hypothesis test ^c 1: Test statistic:	7.600 ^{***}			
Hypothesis test 2: Test statistic:	5.554 ^{**}			
Hypothesis test 3: Test statistic:	7.008 ^{***}			
<i>Panel B: Volatility</i>				
β_1	0.792 (11.66) ^{***}	0.622 (9.90) ^{***}	0.783 (10.49) ^{***}	0.602 (9.28) ^{***}
β_2			0.099 (1.73) [*]	0.164 (3.28) ^{***}
R^2	0.627	0.547	0.598	0.570
Hypothesis test 1: Test statistic:	9.677 ^{***}			
Hypothesis test 2: Test statistic:	2.134			
Hypothesis test 3: Test statistic:	5.506 ^{***}			
<i>Panel C: Volume</i>				
β_1	30.675 (2.34) ^{**}	2.089 (4.29) ^{***}	28.763 (2.23) ^{**}	1.955 (3.81) ^{***}
β_2			35.006 (3.29) ^{***}	0.626 (1.48)
R^2	0.065	0.189	0.184	0.189
Hypothesis test 1: Test statistic:	4.840 ^{**}			
Hypothesis test 2: Test statistic:	10.605 ^{***}			
Hypothesis test 3: Test statistic:	8.460 ^{***}			

(Continued)

TABLE I
Baseline SUR Model Estimation^a and Hypotheses Tests (*Continued*)

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel D: Bid–ask spread</i>				
β_1	0.020 (5.48)***	0.022 (6.64)***	0.021 (5.35)***	0.023 (6.19)***
β_2			−0.001 (−0.46)	0.001 (0.46)
R^2	0.270	0.353	0.262	0.331
Hypothesis test 1: Test statistic:	0.562			
Hypothesis test 2: Test statistic:	1.496			
Hypothesis test 3: Test statistic:	0.946			

^aSUR model specifications are as follows: (a) For the one-factor model:

$$y_{B,t} = \alpha_B + \beta_{B,1}S_{FF,t} + \varepsilon_{Bt}$$
$$y_{S,t} = \alpha_S + \beta_{S,1}S_{FF,t} + \varepsilon_{St}$$

(b) For the two-factor model:

$$y_{B,t} = \alpha_B + \beta_{B,1}S_{FF,t} + \beta_{B,2}S_{FS,t} + \varepsilon_{Bt}$$
$$y_{S,t} = \alpha_S + \beta_{S,1}S_{FF,t} + \beta_{S,2}S_{FS,t} + \varepsilon_{St}$$

$y_{B,t}$ and $y_{S,t}$ are S&P 500 and S&P 400 return (raw return multiplied by 1000), volatility, volume (raw volume divided by 1,000) and bid–ask spread of the 5-minute interval after FOMC statements. For return regressions, $S_{FF,t}$ is the tight window surprise in the one-factor model and the target factor in the two-factor model. $S_{FS,t}$ is the path factor in Gurbaynak et al. (2005). For volatility, volume, bid–ask spread regressions, $S_{FF,t}$ is the absolute value of the tight window surprise in the one-factor model and the absolute value of the target factor in the two-factor model. $S_{FS,t}$ is the absolute value of the path factor.

^bThe t statistics are in parentheses.

^cHypothesis test specifications: Hypothesis test 1: $\beta_{B,1} = \beta_{S,1}$ in the one-factor model. Hypothesis test 2: $\beta_{B,2} = \beta_{S,2}$ in the two-factor model. Hypothesis test 3: $\beta_{B,1} = \beta_{S,1}$; $\beta_{B,2} = \beta_{S,2}$ in the two-factor model

**Significance at 5%.

***Significance at 1%.

in the target factor, the above result indicates that an unanticipated 25-basis-point decline in the four-quarter-ahead eurodollar futures rate due to the new information in the FOMC statements is associated with a rise of 0.37% in the SPY during the first 5 minutes. Clearly, there is additional information in the FOMC statements other than the surprises in the federal funds rate target. The hypothesis tests indicate that the SPY and MDY react differently to the target factor and the path factor, with the SPY fund reacting more strongly to the surprises in the policy changes during the first 5 minutes’ trading. This result is not well in line with the credit channel hypothesis that suggests small companies

reacting more strongly to monetary policy changes. This issue will be examined in more detail below.

Panel B exhibits the results from the volatility regressions. Volatility is defined as the absolute value of the 5-minute return immediately after FOMC announcements. The absolute values of the federal funds rate target surprise, the target factor, and the path factor are used as independent variables. The impacts of surprises in the federal funds rate target on the SPY and the MDY 5-minute return volatility are similar to their impact on the 5-minute returns. The volatility of the SPY (MDY) generally increases by approximately 8% (6%), given a 1% change in the federal funds rate target. This translates to a 2% (1.5%) increase in the SPY (MDY) return volatility for an unanticipated 25 basis-point change in the federal funds rate target. Both coefficients are statistically significant at the 1% level. The effect of the path factor is significant for the SPY fund at the 10% level and at the 1% level for the MDY fund, with the MDY volatility reacting more strongly to the path factor. The hypothesis test suggests that the impact of the target factor on the SPY is more pronounced.

Panel C shows the results on the volume of trade. The volume of trade is defined as the total number of shares traded during the 5-minute interval divided by 1000. As the SPY is traded more frequently and with a higher volume, the impacts of the federal funds rate target surprise and the surprise in future path of the interest rate on the volume of trade are greater for the SPY fund than for the MDY fund, which is supported by the hypothesis test. Both coefficients for the target factor and the path factor are statistically significant except for the path factor on MDY, suggesting an increase in the volume of trade for both ETFs during the first 5 minutes after the monetary policy changes.

The effect of the federal funds rate target surprise is statistically significant on the bid-ask spread for both SPY and MDY ETFs. Here the bid-ask spread is defined as the average bid-ask spread within the first 5 minutes of the policy changes. However, the coefficients for the path factor are not statistically significant for either the SPY or the MDY, although the hypothesis tests confirm that there is no difference in the impacts of the target factor on the average bid-ask spread for the two ETFs.

In summary, the above results suggest that both the target and path factors have statistically significant and different impacts on the 5-minute returns, volatilities, and volumes of trade of the two ETF funds, with the impact of the target factor generally stronger than that of

the path factor and the impact of target factor on SPY generally stronger than that on the MDY.

ASYMMETRY AND PRICE ADJUSTMENT

Asymmetric Response of Returns

In this subsection, the impact of FOMC announcements on the 5-minute returns after the announcements is further examined by exploring potential asymmetric impacts of monetary policy announcements.

Sign Response

One possibility of asymmetry is that the magnitude of the ETFs' responses depends on the sign of the surprises. During the sample period, there are 29 positive surprises and 38 negative surprises in the federal fund target rate changes. To allow for the asymmetry, four dummy variables are created with D_1^+ as 1 when there are unanticipated positive surprises in the federal funds rate target in the one-factor model and when the target factor is positive in the two-factor model; D_1^- as 1 with negative surprises in the federal funds rate target in the one-factor model and negative target factor in the two-factor model; D_2^+ as 1 with positive surprises in the path factor, and D_2^- as 1 with negative surprises in the path factor. As there are many observations of no surprises in both the target (the surprise in the federal funds rate target) and the path factor, the model is free from the trap of the dummy variable problem. The following one-factor and two-factor regressions are then estimated with the use of SUR:

$$r_{i,t} = \alpha_i + \beta_{i,1}^+ D_1^+ \Delta Fundrate^U + \beta_{i,1}^- D_1^- \Delta Fundrate^U + \varepsilon_{it} \quad (\text{one-factor}) \quad (3)$$

$$r_{i,t} = \alpha_i + \beta_{i,1}^+ D_1^+ s_{FF,t} + \beta_{i,1}^- D_1^- s_{FF,t} + \beta_{i,2}^+ D_2^+ s_{FS,t} + \beta_{i,2}^- D_2^- s_{FS,t} + \varepsilon_{it} \quad (\text{two-factor}) \quad (4)$$

where the symbols are defined as in Equations (1) and (2).

Panel A of Table II presents the results of the sign regressions. The result suggests that positive surprises in the target factor (or surprises in the federal funds rate target) generally have no statistically significant impacts on the returns of the two ETFs, whereas negative surprises have statistically significant impacts on both the SPY and MDY returns. Because of this asymmetry, an unanticipated 25-basis-point cut in the

federal funds rate target (or the target factor), in the absence of any surprises in the accompanying FOMC statements, leads to an increase of approximately 2.2% in the SPY, and 1.8% increase in the MDY in the one- and two-factor models. Compared to the baseline results, the impacts of the federal funds rate target surprises come mostly from the unanticipated cuts in the federal funds rate target, and the unanticipated increases in the federal funds rate target have little economically significant impacts. These findings are different from Bernanke and Kuttner (2005), who find no such sign related asymmetric effects on CRSP value-weighted index using daily data.

TABLE II
Return Regressions

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
Panel A: Sign response				
β_1^+	0.100 (0.43)	0.122 (0.59)	0.015 (0.08)	0.027 (0.15)
β_1^-	-0.891 (-11.74)***	-0.736 (-10.90)***	-0.903 (-11.40)***	-0.750 (-10.27)***
β_2^+			-0.008 (-0.10)	-0.005 (-0.06)
β_2^-			-0.101 (-1.43)	0.028 (0.42)
R^2	0.638	0.602	0.651	0.589
Hypothesis test 1: Test statistic:	8.343***			
Hypothesis test 2: Test statistic:	4.058**			
Hypothesis test 3: Test statistic:	1.039			
Hypothesis test 4: Test statistic:	3.623**			
Panel B: Size response				
β_1^B	-0.757 (-10.58)***	-0.621 (-9.80)***	-0.739 (-10.32)***	-0.582 (-8.89)***
β_1^S	0.032 (0.05)	0.127 (0.22)	-0.912 (-2.21)**	-1.003 (-2.66)***
β_2^B			-0.096 (-2.02)**	-0.017 (-0.39)
β_2^S			0.479 (1.55)	0.249 (0.88)
R^2	0.580	0.543	0.597	0.532
Hypothesis test 1: Test statistic:	0.868			
Hypothesis test 2: Test statistic:	3.804**			
Hypothesis test 3: Test statistic:	1.941			
Hypothesis test 4: Test statistic:	3.699**			

(Continued)

TABLE II
Return Regressions (*Continued*)

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel C: Direction of rate movement</i>				
β_1^I	0.407 (1.02)	0.012 (0.04)	0.465 (1.46)	0.140 (0.50)
β_1^D	-0.818 (-11.30)***	-0.681 (-10.73)***	-0.820 (-10.88)***	-0.676 (-10.16)***
β_2^I			-0.388 (-1.78)*	-0.320 (-1.66)*
β_2^D			-0.001 (-0.01)	0.104 (1.38)
R^2	0.614	0.587	0.600	0.567
Hypothesis test 1: Test statistic:	4.587**			
Hypothesis test 1: Test statistic:	4.428**			
Hypothesis test 1: Test statistic:	2.140			
Hypothesis test 1: Test statistic:	2.140			

Notes. 1. SUR model specifications. Panel A: Sign response. One-factor model:

$$r_{B,t} = \alpha_B + \beta_{B,1}^+ D_1^+ s_{FF,t} + \beta_{B,1}^- D_1^- s_{FF,t} + \varepsilon_{Bt}$$

$$r_{S,t} = \alpha_S + \beta_{S,1}^+ D_1^+ s_{FF,t} + \beta_{S,1}^- D_1^- s_{FF,t} + \varepsilon_{St}$$

where $r_{B,t}$ and $r_{S,t}$ are S&P 500 and S&P 400 return (raw return multiplied by 1000) of the 5-minute interval after FOMC statements. $s_{FF,t}$ is the tight window surprise in Gurbaynak et al. (2005). D_1^+ = positive surprise in the tight window, D_1^- = negative surprise in the tight window.

Two-factor model:

$$r_{B,t} = \alpha_B + \beta_{B,1}^+ D_1^+ s_{FF,t} + \beta_{B,1}^- D_1^- s_{FF,t} + \beta_{B,2}^+ D_2^+ s_{FS,t} + \beta_{B,2}^- D_2^- s_{FS,t} + \varepsilon_{Bt}$$

$$r_{S,t} = \alpha_S + \beta_{S,1}^+ D_1^+ s_{FF,t} + \beta_{S,1}^- D_1^- s_{FF,t} + \beta_{S,2}^+ D_2^+ s_{FS,t} + \beta_{S,2}^- D_2^- s_{FS,t} + \varepsilon_{St}$$

where $s_{FF,t}$ is the target factor and $s_{FS,t}$ is the path factor in Gurbaynak et al. (2005). D_1^+ = positive surprises in the target factor, D_1^- = negative surprises in the target factor, D_2^+ = positive surprises in the path factor, D_2^- = negative surprises in the path factor.

Panel B: Size response: One-factor model: Same as that for sign response, except D_1^+ is replaced by D_1^b and D_1^- by D_1^s , where D_1^b = big surprises in the tight window surprise (upper 50% in terms of *absolute* value), D_1^s = small surprises in the tight window surprise (lower 50% in terms of *absolute* value). Two-factor model: Same as that for sign response, except D_1^+ is replaced by D_1^b , D_1^- by D_1^s , D_2^+ by D_2^b and D_2^- by D_2^s , where D_1^b = big surprises in the target factor (upper 50% in terms of *absolute* value), D_1^s = small surprises in the target factor (lower 50% in terms of *absolute* value). D_2^b = big surprises in the path factor (upper 50% in terms of *absolute* value), D_2^s = small surprises in the path factor (lower 50% in terms of *absolute* value).

Panel C: Direction of rate movement: One-factor model:

$$r_{B,t} = \alpha_B + \beta_{B,1}^I D_1^I s_{FF,t} + \beta_{B,1}^D D_1^D s_{FF,t} + \varepsilon_{Bt}$$

$$r_{S,t} = \alpha_S + \beta_{S,1}^I D_1^I s_{FF,t} + \beta_{S,1}^D D_1^D s_{FF,t} + \varepsilon_{St}$$

where D_1^I = increase in the federal funds rate target (FF), D_1^D = decrease in FF. Two-factor model:

$$r_{B,t} = \alpha_B + \beta_{B,1}^I D_1^I s_{FF,t} + \beta_{B,1}^D D_1^D s_{FF,t} + \beta_{B,2}^I D_1^I s_{FS,t} + \beta_{B,2}^D D_1^D s_{FS,t} + \varepsilon_{Bt}$$

$$r_{S,t} = \alpha_S + \beta_{S,1}^I D_1^I s_{FF,t} + \beta_{S,1}^D D_1^D s_{FF,t} + \beta_{S,2}^I D_1^I s_{FS,t} + \beta_{S,2}^D D_1^D s_{FS,t} + \varepsilon_{St}$$

2. The t statistics are in parentheses.

3. Hypothesis tests specifications: Hypothesis test 1: $\beta_{B,1}^D = \beta_{B,1}^I$; $\beta_{S,1}^D = \beta_{S,1}^I$ in the one factor model. Hypothesis test 2: $\beta_{B,1}^D = \beta_{S,1}^D$; $\beta_{B,1}^I = \beta_{S,1}^I$ in the one factor model. Hypothesis test 3: $\beta_{B,2}^D = \beta_{B,2}^I$; $\beta_{S,2}^D = \beta_{S,2}^I$ in the two factor model. Hypothesis test 4: $\beta_{B,2}^D = \beta_{S,2}^D$; $\beta_{B,2}^I = \beta_{S,2}^I$ in the two factor model.

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

Hypothesis testing further confirms that the negative surprises in the federal funds rate target (or the target factor) have statistically significant and larger impact on two ETF returns than the positive surprises. It also shows that the impact of the surprises is different between the two ETFs with the SPY reacting more strongly to the surprise.

Size Response

The surprises in the target and path factors are also divided into large and small surprises by creating new sets of dummy variables. D_1^l is termed as large surprises in the federal funds rate target (one-factor model) or in the target factor (two-factor model), if the surprise is among the upper 50% in terms of *absolute* values of all surprises, D_1^s as small surprises if the surprise is among the lower 50%. D_2^l and D_2^s are defined in similar fashions. Christie-David et al. (2003) use a similar specification to examine the asymmetric impact of macroeconomic news on bond trading. The following SUR regressions are estimated:

$$r_{i,t} = \alpha_i + \beta_{i,1}^l D_1^l \Delta Fundrate_t^U + \beta_{i,1}^s D_1^s \Delta Fundrate_t^U + \varepsilon_{it} \quad (5)$$

$$r_{i,t} = \alpha_i + \beta_{i,1}^l D_1^l s_{FF,t} + \beta_{i,1}^s D_1^s s_{FF,t} + \beta_{i,2}^l D_2^l s_{FS,t} + \beta_{i,2}^s D_2^s s_{FS,t} + \varepsilon_{it} \quad (6)$$

Panel B in Table II presents the results on size responses. In both the one-factor and two-factor models, the impact of large surprises in the target factor generally is more statistically significant (at the 1% level) on the returns of the two ETF funds. Hypothesis testing, however, indicates that there is no significant difference between the impacts of the large and small surprises in the target factor. In addition, the path factor is generally not statistically significant, except that large surprises in the path factor have a statistically significant impact on the SPY returns at the 5% level.

Direction of Rate Movement

Further examination is made of whether the impacts of monetary policy surprises differ during expansionary or tightening periods of the monetary policy. For that purpose, a dummy variable D_1^I is created as 1 if there is an increase in the federal funds rate, and D_1^D as 1 if there is a decline in the funds rate. This specification follows Bernanke and Kuttner (2005) and Jensen, Johnson, & Mercer (1996). There are 13 rate

increases and 19 rate decreases during the sample period. Specifically, the following model is estimated:

$$r_{i,t} = \alpha_i + \beta_{i,1}^I D_1^I \Delta Fundrate^U + \beta_{i,1}^D D_1^D \Delta Fundrate^U + \varepsilon_{it} \quad (7)$$

$$r_{i,t} = \alpha_i + \beta_{i,1}^I D_1^I s_{FF,t} + \beta_{i,1}^D D_1^D s_{FF,t} + \beta_{i,2}^I D_1^I s_{FS,t} + \beta_{i,2}^D D_1^D s_{FS,t} + \varepsilon_{it} \quad (8)$$

Note that in Equation (8), the same dummy variables are used for both the target and path factors, as separate dummy variables for the path factor cannot be meaningfully defined.

The results in Panel C of Table II suggest that surprises in the federal funds rate target changes (or the target factor) have statistically significant impact on the returns of both the SPY and the MDY only when the monetary policy ($D_1^D = 1$) is expansionary. This result complements that in Panel A where only unexpected rate cuts matter. But, it again differs from Bernanke and Kuttner (2005), where the direction of rate movements is not found to be an important determinant of the market's reaction with the use of daily data. Further hypothesis testing from the one-factor model confirms that the effect of monetary policy surprises on the ETF returns during the period of a rate cut is statistically different from those during the period of a rate increase, and the effect of a rate cut is also stronger for the SPY than for the MDY during the first 5 minutes' trading. Moreover, it is interesting to note that surprises in the path factor have statistically significant impact on the SPY and MDY returns only during the periods when there is a monetary tightening. This result is quite intriguing: During the period of monetary tightening, the market reacts more toward future monetary policy changes, whereas during the period of monetary loosening, the market concentrates more on current rate target changes.⁸

Thus, there is strong indication that ETFs react asymmetrically to signs of surprises in monetary policy and monetary policy regimes. Because FOMC statements were issued sporadically from February 1994 to May 1999, and were issued after every meeting starting from May 1999, the robustness check on the findings is conducted by using the whole sample period but with observations without FOMC

⁸The potential asymmetry related to business cycles is also investigated (results available on request). Following the suggestion of Andersen et al. (2003, p. 50) and the NBER business cycle dating, an economic expansion dummy variable is created from the beginning of the sample until February 28, 2001, and an economic recession dummy variable from March 1, 2001, to November 30, 2001 (which only involves seven observations). There is some evidence that the impact of the target factor and path factor surprises on the SPY returns is greater than that on MDY returns, especially during the economic expansionary environment.

statements dropped, and by using the smaller sample period of May 1999 to December 2004. Overall, the results are qualitatively the same and quantitatively very similar.⁹

Another robustness check is to examine the impact of potential outliers. As in Hadi (1994) outliers were detected in multivariate analysis and six influential observations (July 6, 1995; October 15, 1998; January 3, 2001; April 18, 2001; November 6, 2002; and January 28, 2004) were identified at the 1% significance level. These observations mostly coincide with large surprises rather than small surprises (as defined in this study), and they are not necessarily the first rate changes in a series of policy changes. These observations are dropped from the regressions when re-conducting the analysis. The results (not reported here) indicate that asymmetry results are still statistically significant for the five-minute returns regression and qualitatively unchanged.¹⁰

Persistence of Returns Response

To examine how quickly ETF prices react to the monetary policy surprises, the same previous specification is used, but with the 5-minute returns immediately after the policy changes replaced with returns 5 minutes before the monetary policy changes, 5 minutes after, returns between the 5-minute mark and the 10-minute mark, 10-minute mark and 15-minute mark, 15-minute mark and 30-minute mark, and 30-minute mark and 45-minute mark after the policy changes. Panel A of Table III presents the regression results with the use of specifications from Equations (1) and (2).

The impact of the target factor is stronger and lasts longer than that of the path factor. The estimated coefficients for the target factor are still statistically significant even after 30 minutes, especially for the SPY. This result is surprising, given that most studies on the macroeconomic news announcements find that the news impact on asset prices only last around 10–15 minutes (e.g., Balduzzi et al., 2001; Ederington & Lee, 1993). However, it is consistent with Adams et al. (2004), who find that it could take at least 1 hour for size-based quintile portfolios to react to PPI and CPI news surprises.

⁹The authors thank the anonymous referee for the suggestion on the robustness check. It is found (results available on request) that such robustness holds not only for returns, but also for volatility, volume and bid–ask spread. It also generally holds across different model specifications of asymmetric responses.

¹⁰The regression results (available on request), however, are somewhat weaker for volatilities, volume and bid–ask spread, which is essentially similar to the finding of Bernanke and Kuttner (2005) on returns.

TABLE III
Return Persistence

	(-5)-0 minutes		0-5 minutes		5-10 minutes		10-15 minutes		15-30 minutes		30-45 minutes	
	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel A: Return persistence with the use of the baseline two-factor model</i>												
β_1	-0.082 (-3.13)***	-0.028 (-1.37)	-0.725 (-0.42)***	-0.591 (-9.36)***	0.073 (1.62)	-0.036 (-0.71)	0.121 (3.17)***	0.091 (3.29)***	-0.020 (-0.57)	-0.063 (-1.20)	0.113 (3.07)***	0.035 (0.78)
β_2	0.066 (3.67)***	0.037 (2.62)***	-0.079 (-1.66)*	-0.004 (-0.10)	-0.055 (-1.78)*	-0.083 (-2.39)**	0.005 (0.18)	0.011 (0.56)	-0.051 (-2.08)**	0.015 (0.43)	0.030 (1.18)	-0.024 (-0.78)
R^2	0.223	0.098	0.579	0.520	0.067	0.071	0.111	0.121	0.054	0.020	0.118	0.015
Hypothesis 1	3.610*		8.449***		5.885**		0.679		0.807		2.986*	
Hypothesis 2	2.217		5.554**		0.785		0.051		4.179**		3.068*	
Hypothesis 3	2.911*		7.008***		3.337**		0.365		2.491*		3.030*	
<i>Panel B: Return persistence with the use of the two-factor model with sign response dummies</i>												
β_1^+	-0.033 (-0.42)	0.044 (0.73)	0.015 (0.08)	0.027 (0.15)	-0.443 (-3.61)***	-0.371 (-2.49)**	0.203 (1.76)*	0.116 (1.38)	0.001 (0.01)	0.157 (0.99)	-0.131 (-1.21)	-0.180 (-1.33)
β_1^-	-0.101 (-3.11)***	-0.056 (-2.30)**	-0.903 (-11.40)***	-0.750 (-0.27)***	0.191 (3.81)***	0.049 (0.81)	0.093 (1.97)*	0.082 (2.40)**	-0.028 (-0.63)	-0.112 (-1.74)*	0.168 (3.80)***	0.081 (1.46)
β_2^+	0.034 (1.03)	-0.015 (-0.59)	-0.008 (-0.10)	-0.005 (-0.06)	-0.139 (-2.75)***	-0.091 (-1.48)	-0.033 (-0.70)	0.002 (0.05)	-0.063 (-1.40)	0.054 (0.83)	-0.012 (-0.28)	-0.080 (-1.44)
β_2^-	0.096 (3.32)***	0.084 (3.85)***	-0.101 (-1.43)	0.028 (0.42)	-0.012 (-0.27)	-0.093 (-1.72)*	0.041 (0.97)	0.019 (0.63)	-0.040 (-1.01)	-0.006 (-0.10)	0.052 (1.32)	0.011 (0.23)
R^2	0.242	0.195	0.651	0.589	0.267	0.132	0.128	0.124	0.056	0.049	0.183	0.060
Hypothesis 1	1.067		8.637***		9.534***		0.322		1.181		3.038*	
Hypothesis 2	1.645		4.025**		3.380**		0.411		1.304		1.571	
Hypothesis 3	3.606**		1.039		1.910		0.517		0.428		0.748	
Hypothesis 4	1.271		3.623**		1.456		0.323		2.923*		1.519	

Note. See the note in Table I (for Panel A) and Table II (for Panel B).

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

The estimated coefficients for the target factor are statistically negative within the first 5 minutes of the policy changes, but fluctuate between positive and negative after the first 5 minutes, indicating information processing by the market participants. The cumulative impact of the target factor for the first 5 (or 45) minutes on SPY returns is -0.725 (or -0.438), suggesting a change of 1.81% (or 1.1%) in the SPY for an unanticipated 25-basis-point change in the federal funds rate target.¹¹ Bernanke and Kuttner (2005) and Gurkaynak et al. (2005) find that the overall stock index rises about 1% for an unanticipated 25-basis-point rate cut with the use of daily data. The present results suggest the SPY initially overreacts to unanticipated federal funds rate changes during the first 5 minutes after the policy changes. By contrast, the cumulative impact of the target factor for the first 5 (or 45) minutes on MDY returns is -0.591 (or -0.564), or 1.48 (or 1.41) percent change in the MDY for an unanticipated 25-basis-point change in the federal funds rate target. Therefore, the response of the MDY to the federal funds rate target changes is mostly captured during the first 5 minutes' trading.

The less strong reaction of MDY to the target factor during the first 5 minutes, compared with that of SPY, is consistent with Adams et al. (2004), where small stock portfolios are found to show less significant response to inflation news than their large counterparts. One reason may be that the MDY is not traded as frequently as the SPY, which has been argued by Chordia and Swaminathan (2000). Mech (1993) offers another explanation that small stocks, due to their higher transaction costs, may show a less-significant concurrent response than large stocks to common news. Because the MDY's average bid-ask spread is higher than that of the SPY, it is also consistent with the story by Mech (1993). Still in this case, the apparent smaller reaction of MDY during the first 5 minutes compared with SPY is due to the overreaction of SPY, because, after 45 minutes, the cumulative impact of the target factor on MDY is greater than that on SPY. This result is in line with the credit channel hypothesis. According to the credit-channel theory of monetary transmission mechanism, smaller firms are more severely affected by changes in monetary policy than larger firms. Therefore, smaller stocks could react more strongly to monetary policy surprises than larger stocks after a prolonged period of trading, which could be due to a larger change in future expected cash flows or a larger change in future expected equity premium.

¹¹Note that the dependent variable is the actual return times 1,000.

The estimated coefficients for the path factor stay negative and statistically significant within 10 minutes of the policy changes, but become statistically insignificant after 30 minutes. The cumulative impact of the path factor for the first 10 (45) minutes on the SPY returns is -0.134 (-0.15), a change of 0.63% (0.71%) in the SPY for an unanticipated 25-basis-point change in the four-quarter-ahead eurodollar futures rates due to the new information in the FOMC statements. The cumulative impact of the path factor for the first 10 (45) minutes on the MDY returns is -0.087 (-0.085), a change of 0.41 (0.40) percent in the MDY for an unanticipated 25-basis-point change in the federal funds rate target. Therefore, the impact of the path factor on the two ETF returns is smaller than that of the target factor, even 45 minutes after policy changes.

For robustness check, Panel B of Table III presents the persistence results based on the alternative specification with the sign response dummies. For an unanticipated decline in the target factor, there is again a strong overreaction for the impact of the target factor on the SPY returns in the first 5 minutes of the trading: An unanticipated 25-basis-point cut leads to an increase of approximately 2.3% in the SPY. For MDY, the increase is 1.9% . After 45 minutes, however, the cumulative impact is -0.479 for the SPY and -0.65 for the MDY, indicating a rise of 1.2% for the SPY and 1.6% for the MDY with an unanticipated 25-basis-point cut. For an unanticipated increase in the target factor, there is a delayed reaction, and the impacts are small and statistically insignificant in the first 5 minutes. For the next 5 minutes, the impacts are statistically significant, and are -0.443 and -0.371 for the SPY and the MDY, respectively, indicating a decline of 1.1% and 0.93% for an unanticipated 25-basis-point increase in the federal funds rate target. Afterwards, the impacts are generally statistically insignificant. Overall, for the first 45 minutes, there is a decline of 0.88% for the SPY and a decline of 0.63% for the MDY for an unanticipated 25-basis-point increase in the federal funds rate target. In sum, the return response of the SPY and the MDY to the unanticipated decline in the federal funds rate target is faster, stronger, and lasts longer than the unanticipated increase in the target factor. Also, the difference between the impacts on the SPY of unanticipated decline and increase in the federal funds rate target becomes smaller in the 45 minutes, although such differential impacts on MDY still remains rather noticeable. Compared with Bernanke and Kuttner (2005), who report no such asymmetric impact on the CRSP value-weighted index with the use of daily data, the present results suggest there are indeed asymmetric responses.

The impact of the path factor is not as strong as that of the target factor, for either positive or negative unanticipated shocks. Statistically, the impact is not important in the first 5 minutes after the FOMC announcements. For the next 5 minutes, the effect of a positive surprise in the path factor on the SPY is -0.139 and statistically significant. This suggests that the SPY declines by 0.69% for the first 10 minutes for an unanticipated 25-basis-points increase in the four-quarter-ahead eurodollar futures due to the new information in the FOMC statements.

Although the impact of the path factor on the SPY and the MDY is generally not strong, there is a strong preannouncement effect of the path factor on both the SPY and MDY 5 minutes before the announcements, especially when there is a negative surprise on the path factor. The coefficients (0.096 and 0.082 for SPY and MDY, respectively) for the negative surprise suggest that the ETF prices increase before the announcement when there is an unanticipated decline for the 1-year-ahead eurodollar futures rate. This preannouncement effect is also significant for the unanticipated decline in the target factor with negative coefficients.

Asymmetric Response of Price Volatility

Following the literature, volatility is defined as absolute values of 5-minute returns. The same set of regressions based on Equations (3)–(10) are employed here with two important changes. First, regular 5-minute returns are replaced with absolute values of 5-minute returns. Second, following Andersen et al. (2003), for independent variables, absolute values of surprises in federal funds rate target, the target, and the path factors are used.

The results from Panel A of Table IV on sign response show that positive surprises in the target factor generally do not have statistically significant impact on the volatilities of the two ETFs while the negative surprises have statistically significant impact. Due to this asymmetry, an unanticipated 25-basis-point cut in the federal funds rate target (or the target factor), in the absence of any surprises in the accompanying FOMC statements, leads to an increase of 2% rise in the SPY volatility and roughly 1.6% increase in the MDY volatility within the first 5 minutes of the policy change. Compared with the baseline results, the sign regression suggests that in the first 5 minutes, the impact of the surprises in the federal funds rate target come mostly from the unanticipated cut in the federal funds rate target, whereas unanticipated increases in the federal funds rate do not have an economically significant impact. The result is similar to that on the returns response. Hypothesis testing further confirms that negative surprises in the

federal funds rate target have a larger impact on the ETF volatilities than positive surprises. It also suggests that the impact of negative surprises is different for the two ETFs, with the SPY reacting more strongly to the surprises. Similar results on the sign effects of macroeconomic news announcements have also been reported in Christie-David et al. (2003).

The coefficients for the path factor are statistically significant for the MDY, but not for SPY, which is different from the sign regression result on the returns that nearly all the coefficients are statistically insignificant in the first 5 minutes. Therefore, the MDY volatility reacts significantly to both factors, whereas the SPY volatility reacts only to the target factor.

TABLE IV
Volatility Regressions

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
Panel A: Sign response				
β_1^+	0.367 (1.81)*	0.223 (1.19)	0.227 (1.33)	0.153 (1.01)
β_1^-	0.808 (12.18)***	0.637 (10.39)***	0.818 (11.71)***	0.626 (10.17)***
β_2^+			0.104 (1.49)	0.129 (2.08)**
β_2^-			0.072 (1.16)	0.170 (3.10)***
R^2	0.648	0.574	0.655	0.620
Hypothesis test 1 test statistic:	3.046**			
Hypothesis test 2 test statistic:	4.852***			
Hypothesis test 3 test statistic:	0.702			
Hypothesis test 4 test statistic:	1.867			
Panel B: Size response				
β_1^B	0.791 (11.27)***	0.627 (9.65)***	0.762 (9.96)***	0.617 (9.25)***
β_1^S	0.757 (1.07)	0.823 (1.26)	0.389 (0.94)	0.921 (2.55)**
β_2^B			0.105 (1.61)	0.173 (3.05)***
β_2^S			0.285 (0.69)	0.209 (0.58)
R^2	0.627	0.548	0.604	0.574
Hypothesis test 1 test statistic:	0.103			
Hypothesis test 2 test statistic:	4.936***			
Hypothesis test 3 test statistic:	0.161			
Hypothesis test 4 test statistic:	1.865			

(Continued)

TABLE IV
(Continued)

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel C: Direction of rate movement</i>				
β_1^I	0.587 (1.54)	0.128 (0.37)	−0.066 (−0.19)	−0.425 (−1.33)
β_1^D	0.750 (10.95)***	0.600 (9.79)***	0.709 (8.55)***	0.603 (8.03)***
β_2^I			0.451 (1.79)*	0.430 (1.89)*
β_2^D			0.110 (1.16)	−0.009 (−0.10)
R^2	0.597	0.544	0.594	0.530
Hypothesis test 1 test statistic:	1.197			
Hypothesis test 2 test statistic:	4.755**			
Hypothesis test 3 test statistic:	1.669			
Hypothesis test 4 test statistic:	1.375			

Note. See the notes in Table 2 for model specifications and hypothesis tests. The dependent variables here are absolute values of S&P 500 and S&P 400 returns in the 5-minute interval after FOMC statements. The independent variables are absolute values of tight window surprises (one factor model), absolute values of target factors (two factor model) and absolute values of path factors.

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

Panel B in Table IV shows that large surprises in the target factor generally have statistically significant impact on the volatilities of the two ETFs, and most small surprises do not. The coefficients of the big surprises in the path factor are statistically significant for the MDY but not for the SPY. Panel C of Table III suggests that the federal funds rate target surprises have statistically significant impact on both the SPY and MDY volatilities in the first 5 minutes only during the period of a rate decline. However, the surprises in the path factor have statistically significant impact on the SPY and MDY volatilities only during the period of a rate increase, which is consistent with the result on the returns.

Persistence of Price Volatility Response

Table V presents how quickly volatilities react to monetary policy surprises. Similar to the finding on the returns, Panel A shows that the impact of the target factor on volatility is stronger and lasts longer than

TABLE V
Volatility Persistence

	(-5)-0 minutes		0-5 minutes		5-10 minutes		10-15 minutes		15-30 minutes		30-45 minutes	
	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel A: Volatility persistence using the baseline two-factor model</i>												
β_1	0.098 (3.51)***	0.018 (0.88)	0.783 (10.49)***	0.602 (9.28)***	0.129 (3.32)***	0.111 (2.39)**	0.130 (3.42)***	0.072 (2.51)**	0.060 (2.08)**	0.172 (3.52)***	0.143 (4.78)***	0.138 (3.25)***
β_2	0.042 (1.97)*	0.027 (1.72)*	0.099 (1.73)*	0.164 (3.28)***	0.059 (1.98)**	0.110 (3.11)***	0.016 (0.54)	0.015 (0.69)	0.070 (3.19)***	0.068 (1.81)*	0.017 (0.73)	0.052 (1.59)
R^2	0.186	0.050	0.598	0.570	0.174	0.180	0.136	0.084	0.171	0.180	0.234	0.154
Hypothesis 1	6.760***		9.937***		0.123		2.164		4.809**		0.013	
Hypothesis 2	0.402		2.134		1.715		0.000		0.003		1.147	
Hypothesis 3	3.881**		5.506***		0.872		1.105		2.435*		0.574	
<i>Panel B: Volatility persistence using the two-factor model with sign response dummies</i>												
β_1^+	0.113 (1.64)	0.063 (1.32)	0.227 (1.33)	0.153 (1.01)	0.346 (3.84)***	0.202 (1.78)*	0.082 (0.88)	-0.037 (-0.54)	0.050 (0.70)	0.071 (0.60)	0.125 (1.70)*	0.101 (0.96)
β_1^-	0.097 (3.47)***	0.012 (0.60)	0.818 (11.71)***	0.626 (10.17)***	0.121 (3.28)***	0.103 (2.23)**	0.132 (3.45)***	0.075 (2.67)***	0.060 (2.09)**	0.183 (3.81)***	0.143 (4.73)***	0.140 (3.26)***
β_2^+	0.047 (1.66)*	-0.007 (-0.37)	0.104 (1.49)	0.129 (2.08)**	0.114 (3.08)***	0.094 (2.01)**	0.007 (0.18)	-0.020 (-0.72)	0.073 (2.49)**	0.116 (2.40)**	0.001 (0.05)	0.047 (1.08)
β_2^-	0.039 (1.57)	0.054 (3.08)***	0.072 (1.16)	0.170 (3.10)***	0.028 (0.86)	0.126 (3.07)***	0.020 (0.58)	0.036 (1.45)	0.068 (2.65)***	0.029 (0.68)	0.027 (1.00)	0.054 (1.41)
R^2	0.187	0.151	0.655	0.620	0.266	0.193	0.140	0.143	0.171	0.219	0.240	0.156
Hypothesis 1	0.615		7.232***		3.355**		1.427		0.490		0.081	
Hypothesis 2	4.058**		5.720***		0.688		1.415		3.072**		0.027	
Hypothesis 3	4.354**		0.702		3.017*		1.689		1.343		0.295	
Hypothesis 4	2.273		1.867		3.077**		0.500		1.083		0.623	

Note. See the notes in Table I (for Panel A) and Table IV (for Panel B).

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

that of the path factor. The estimated coefficients for the target factor are statistically significant even 30 minutes after the FOMC announcements, which is consistent with the volatility effect of the macroeconomic news announcements in the literature (e.g., Andersen et al., 2003; Balduzzi et al., 2001; Ederington & Lee, 1993). The impact of the target factor for the first 5 (or between 30 and 45) minutes on SPY returns volatility is 0.78 (or 0.14), suggesting a rise (or decline) of 1.95% (or 0.35%) in the SPY return volatility for an unanticipated 25-basis-point cut (or increase) in the federal funds rate target. The impact of the target factor for the first five (or between 30 and 45) minutes on MDY is 0.60% (or 0.14%), that is, an increase of 1.50% (or 0.35%) in the MDY volatility for an unanticipated 25-basis-point cut in the federal funds rate target. Thus, the impact of the target factor on the SPY is greater than that on the MDY initially, but the impacts become closer to each other after 30 minutes. This result is also consistent with the findings on the returns persistence and shows slower reaction of smaller-sized stocks to unanticipated news (Adams et al., 2004). Furthermore, the estimated coefficients for the path factor are also generally significant for the first 30 minutes.

Panel B of Table V presents the persistence results with the sign response dummies, which yields similar inferences that volatility impacts are mostly from target rate cuts instead of rises. Overall, the evidence suggests that ETF volatilities at various time intervals also react strongly to unanticipated cuts in the federal funds rate target but not to unanticipated rate increases.

TRADING ACTIVITY AND QUOTED BID-ASK SPREADS

Asymmetric Response of Volume of Trade

The literature on macroeconomic news impact typically focuses on the response of returns and volatility to news. Balduzzi et al. (2001) are among the first to examine macroeconomic news effects on trading activities of U.S. treasury bonds. Frino and Hill (2001) also examine macroeconomic news effects on Australian equity index futures return, volatility, volume, and bid-ask spread. However, none of them has investigated the asymmetric effect of news on trading volume and bid-ask spread.

Table VI presents the results of potential asymmetric reaction of trading volumes to the monetary policy surprises. In the regressions, trading volumes are measured by the total number of shares traded in

each time interval, and the dependent variable is raw volume of shares traded divided by 1,000. The independent variables are absolute values of surprises in monetary policies. It is shown in Panel A that negative surprises in the federal funds rate target affect the volume of trade of both the SPY and the MDY, and positive surprises have statistically significant effects on SPY only. The coefficients for the SPY are all greater than those for the MDY, because the volume of trade is larger for SPY. For the path factor, both positive and negative surprises affect the volume of trade of SPY, but only negative surprises affect the volume of trade of MDY. These results further strengthen the findings in returns

TABLE VI
Volume Regressions

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
Panel A: Sign response				
β_1^+	59.267 (1.48)	1.321 (0.89)	37.103 (1.16)	0.243 (0.19)
β_1^-	29.572 (2.25)**	2.119 (4.33)***	28.016 (2.16)**	2.009 (3.97)***
β_2^+			32.949 (2.51)**	0.185 (0.36)
β_2^-			37.289 (2.85)***	1.019 (2.00)**
R^2	0.071	0.192	0.186	0.224
Hypothesis test 1 test statistic:	0.594			
Hypothesis test 2 test statistic:	2.745*			
Hypothesis test 3 test statistic:	0.976			
Hypothesis test 4 test statistic:	5.383***			
Panel B: Size response				
β_1^B	29.868 (2.20)**	2.055 (4.08)***	32.976 (2.51)**	1.969 (3.72)***
β_1^S	-0.849 (-0.01)	0.753 (0.15)	109.099 (1.53)	2.003 (0.70)
β_2^B			33.161 (2.75)***	0.535 (1.10)
β_2^S			-5.643 (-0.08)	-0.535 (-0.18)
R^2	0.065	0.189	0.203	0.190
Hypothesis test 1 test statistic:	0.049			
Hypothesis test 2 test statistic:	2.447*			
Hypothesis test 3 test statistic:	0.215			
Hypothesis test 4 test statistic:	6.019***			

(Continued)

TABLE VI
(Continued)

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel C: Direction of rate movement</i>				
β_1^I	-38.714 (-0.57)	-0.400 (-0.16)	-38.792 (-0.61)	0.206 (0.09)
β_1^D	35.948 (2.88)***	2.027 (4.28)***	26.014 (1.64)	1.017 (1.77)*
β_2^I			46.461 (1.05)	0.558 (0.35)
β_2^D			23.861 (1.04)	2.521 (3.04)***
R^2	0.104	0.193	0.111	0.273
Hypothesis test 1 test statistic:	0.871			
Hypothesis test 2 test statistic:	4.173**			
Hypothesis test 3 test statistic:	0.892			
Hypothesis test 4 test statistic:	0.938			

Note. See the notes in Table II for model specifications and hypothesis tests. The dependent variables here are volumes (raw volume divided by 1,000) of S&P 500 and S&P 400 in the 5-minute interval after FOMC statements. The independent variables are absolute values of tight window surprises (one-factor model), absolute values of target factors (two-factor model) and absolute values of path factors.

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

and volatility sign regressions that the impact of negative surprises in federal funds rate target changes is stronger for ETF trading.

From Panel B of Table VI, big surprises in the target factor and path factor affect trading of both the SPY and the MDY while small surprises have no effect. In Panel C, surprises in the federal funds rate target affect the volume of trade statistically only when there is a cut in the federal funds rate target. Surprises in the four-quarter-ahead eurodollar rate have an impact on the MDY volume of trade only during the time when federal funds rate target declines, whereas the path factor has no impact on the SPY trading in any cases.

Persistence of Volume of Trade Response

Table VII presents how quickly volume of trade reacts to surprises in the federal funds rate target and surprises in four-quarter-ahead eurodollar rate. The baseline regression shows that the estimated coefficients for the target factor and the path factor are generally statistically significant

TABLE VII
Volume Persistence

	(-5)-0 minutes		0-5 minutes		5-10 minutes		10-15 minutes		15-30 minutes		30-45 minutes	
	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel A: Volume persistence using the baseline two-factor model</i>												
β_1	20.002 (1.26)	-0.158 (-0.47)	28.763 (2.23)**	1.955 (3.81)***	15.271 (1.31)	3.015 (4.58)***	12.978 (1.21)	0.880 (1.74)*	25.661 (1.20)	3.171 (3.48)***	7.975 (0.37)	0.700 (0.28)
β_2	12.539 (0.95)	0.278 (0.99)	35.006 (3.29)***	0.626 (1.48)	49.003 (5.10)***	1.556 (2.86)***	24.526 (2.76)***	0.646 (1.55)	77.327 (4.36)***	0.321 (0.43)	58.653 (3.25)***	-0.942 (-0.45)
R^2	0.035	0.014	0.184	0.189	0.274	0.294	0.113	0.073	0.218	0.140	0.124	0.003
Hypothesis 1	1.601		4.402**		1.115		1.289		1.103		0.114	
Hypothesis 2	0.867		10.605***		24.479***		7.356***		18.937***		11.159***	
Hypothesis 3	1.398		8.460***		13.634***		4.768***		10.734***		5.860***	
<i>Panel B: Volume persistence using the two-factor model with sign response dummies</i>												
β_1^+	67.099 (1.71)*	-0.286 (-0.35)	37.103 (1.16)	0.243 (0.19)	36.509 (1.27)	1.616 (0.99)	57.641 (2.22)**	0.451 (0.37)	-6.495 (-0.12)	1.292 (0.58)	9.105 (0.17)	-2.070 (-0.33)
β_1^-	17.316 (1.09)	-0.190 (-0.56)	28.016 (2.16)**	2.009 (3.97)***	13.903 (1.19)	3.074 (4.65)***	9.820 (0.93)	0.962 (1.93)*	26.494 (1.23)	3.357 (3.71)***	6.710 (0.31)	0.931 (0.37)
β_2^+	14.114 (0.88)	-0.058 (-0.17)	32.949 (2.51)**	0.185 (0.36)	48.368 (4.09)***	1.328 (1.99)**	20.768 (1.94)*	1.133 (2.24)**	67.648 (3.10)***	0.938 (1.03)	48.366 (2.18)**	-0.404 (-0.16)
β_2^-	12.258 (0.77)	0.611 (1.80)*	37.289 (2.85)***	1.019 (2.00)**	50.219 (4.27)***	1.746 (2.63)***	29.505 (2.78)***	0.149 (0.30)	86.110 (3.97)***	-0.346 (-0.38)	68.958 (3.13)***	-1.555 (-0.61)
R^2	0.055	0.048	0.186	0.224	0.280	0.303	0.161	0.109	0.226	0.169	0.131	0.009
Hypothesis 1	0.867		1.291		0.819		2.266		0.632		0.130	
Hypothesis 2	1.678		2.222		0.922		2.495*		0.690		0.045	
Hypothesis 3	1.421		0.976		0.149		2.089		1.048		0.447	
Hypothesis 4	0.499		5.383***		12.517***		4.430**		9.779***		6.015***	

Note. See the notes in Table I (for Panel A) and Table VI (for Panel B).

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

during the first 45 minutes for both the SPY and the MDY. This is consistent with Balduzzi et al. (2001) and Fleming and Remolona (1999), who find a substantial rise in trading volume 30 minutes after news announcements.

For the SPY, the intensity of trading appears to be stronger toward surprises in 1-year-ahead eurodollar rate changes than toward surprises in current federal funds rate target. For the MDY, the reverse tends to be true. Green (2004) documents a significant increase in the informational role of trading following macroeconomic announcements. Balduzzi et al. (2001) also make a similar argument that informed trading likely plays a role as both volatilities and trading volume persist 45 minutes after announcements. Hence, the high intensity of trading for the SPY and the MDY might reflect the enhanced informational role surrounding the uncertainty of the rate target changes that traders try to digest.

Panel B of Table VII presents the persistence results with the sign response dummies. The impact of positive surprises in the federal funds rate target on the SPY is statistically significant until after 15 minutes of the trading, whereas the coefficients are not statistically significant for the MDY trading. The impact of negative surprises in the target factor on the MDY is statistically significant until after 30 minutes of trading, whereas the coefficients for the SPY trading are only statistically significant during the first 5 minutes' trading. Nevertheless, the SPY trading reacts significantly to both positive and negative path factors, whereas the response of the MDY trading is not as strong as the SPY trading.

Asymmetric Response of Quoted Bid–Ask Spreads

The dependent variable is the average quoted bid–ask spread for each time interval, whereas the independent variables are absolute values of surprises in monetary policies. The asymmetry results for the first 5 minutes' trading are presented in Table VIII. The sign response regression suggests that only negative surprises in the federal funds rate target widen the bid–ask spreads while positive surprises generally do not have statistically significant effects, especially for the two-factor model. The results further strengthen the above findings that only negative surprises in federal funds rate target changes affect ETF prices and trading. The path factor generally does not impact the bid–ask spreads of ETF trading.

Panel B shows that big surprises in the target factor have positive effects on the bid–ask spreads of both the SPY and the MDY, whereas

small surprises and path factors have little effect. Panel C further suggests that surprises in the federal funds rate target affect the bid–ask spreads mostly during the time when there is a cut in the federal funds rate target. Surprises in the four-quarter-ahead eurodollar rate do not have a statistically significant impact on the SPY and MDY bid–ask spreads during the time of rate increases or declines. Consistent with the results from the return, volatility, and volumes regressions in the first 5 minutes’ trading, the result here confirms that during the period of a monetary loosening, the market concentrates more on current rate changes.

TABLE VIII
 Bid–Ask Spread Regressions

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
Panel A: Sign response				
β_1^+	0.021 (1.82)*	0.026 (2.53)**	0.010 (1.07)	0.014 (1.62)
β_1^-	0.020 (5.44)***	0.022 (6.57)***	0.022 (5.60)***	0.023 (6.28)***
β_2^+			0.000 (0.11)	0.000 (0.13)
β_2^-			−0.003 (−0.91)	0.002 (0.48)
R^2	0.270	0.354	0.284	0.339
Hypothesis test 1 test statistic:	0.126			
Hypothesis test 2 test statistic:	0.367			
Hypothesis test 3 test statistic:	1.103			
Hypothesis test 4 test statistic:	1.914			
Panel B: Size response				
β_1^B	0.020 (5.29)***	0.023 (6.58)***	0.019 (4.81)***	0.021 (5.84)***
β_1^S	0.020 (0.51)	0.042 (1.19)	−0.025 (−1.16)	−0.011 (−0.56)
β_2^B			−0.003 (−0.94)	−0.002 (−0.57)
β_2^S			−0.013 (−0.62)	−0.032 (−1.62)
R^2	0.270	0.355	0.303	0.372
Hypothesis test 1 test statistic:	0.323			
Hypothesis test 2 test statistic:	0.534			
Hypothesis test 3 test statistic:	1.849			
Hypothesis test 4 test statistic:	1.898			

(Continued)

TABLE VIII
(Continued)

	One-factor model		Two-factor model	
	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel C: Direction of rate movement</i>				
β_1^I	0.070 (3.64)***	0.031 (1.72)*	0.023 (1.29)	0.000 (0.03)
β_1^D	0.020 (5.79)***	0.022 (6.80)***	0.024 (5.79)***	0.022 (5.72)***
β_2^I			0.015 (1.16)	0.012 (1.05)
β_2^D			-0.007 (-1.43)	0.002 (0.41)
R^2	0.3439	0.3679	0.341	0.378
Hypothesis test 1 test statistic:	5.266***			
Hypothesis test 2 test statistic:	4.382**			
Hypothesis test 3 test statistic:	1.410			
Hypothesis test 4 test statistic:	3.273**			

Note. See the notes in Table II for model specifications and hypothesis tests. The dependent variables are bid–ask spreads of S&P 500 and S&P 400 in the 5-minute interval after FOMC statements. The independent variables are absolute values of tight window surprises (one-factor model), absolute values of target factors (two-factor model) and absolute values of path factors.

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

Persistence of Quoted Bid–Ask Spreads Response

Table IX shows that the bid–ask spreads begin to widen significantly in the interval of five minutes before announcements for the MDY. This widening in quoted bid–ask spreads around announcements reflects the fact that market makers adjust quoted spreads in response to increased adverse selection costs, especially for low-liquidity stocks. In the baseline regressions, the surprises in the federal funds rate target increase the bid–ask spreads of both SPY and MDY at least for 45 minutes after announcements. The path factor does not have any effect on the bid–ask spreads whatsoever. The persistence regression with sign response dummies provides additional confirmation and shows that the bid–ask spreads widen only during the period of surprise rate cuts.

One explanation for the result that the bid–ask spreads widen after surprise cuts in the federal funds rate is asymmetric information—that market makers fear that traders might have superior information

TABLE IX
Bid-Ask Spread Persistence

	(-5)-0 minutes		0-5 minutes		5-10 minutes		10-15 minutes		15-30 minutes		30-45 minutes	
	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400	S&P 500	S&P 400
<i>Panel A: Bid-ask spread persistence using the baseline two-factor model</i>												
β_1	0.004 (1.05)	0.021 (3.52)***	0.021 (5.35)***	0.023 (6.19)***	0.018 (5.11)***	0.026 (6.73)***	0.018 (5.60)***	0.022 (6.51)***	0.010 (4.25)***	0.013 (4.49)***	0.011 (4.74)***	0.013 (4.63)***
β_2	-0.000 (-0.11)	0.006 (1.20)	-0.001 (-0.46)	0.001 (0.46)	-0.002 (-0.87)	0.001 (0.51)	-0.003 (-1.39)	0.000 (0.17)	-0.002 (-1.05)	0.000 (0.01)	-0.003 (-1.47)	0.001 (0.61)
R^2	0.013	0.159	0.262	0.331	0.244	0.369	0.282	0.349	0.184	0.203	0.223	0.222
Hypothesis 1	8.207***		0.207		9.181***		2.999*		2.415		1.011	
Hypothesis 2	1.532		1.496		3.805*		3.187*		1.610		5.014**	
Hypothesis 3	5.461***		0.946		7.448***		3.587**		2.328		3.387**	
<i>Panel B: Bid-ask spread persistence using the two-factor model with sign response dummies</i>												
β_1^+	0.007 (0.84)	0.009 (0.61)	0.010 (1.07)	0.014 (1.62)	0.009 (1.02)	0.015 (1.65)	0.011 (1.42)	0.012 (1.40)	0.007 (1.14)	0.011 (1.52)	0.006 (1.14)	0.008 (1.21)
β_1^-	0.004 (1.06)	0.021 (3.57)***	0.022 (5.60)***	0.023 (6.28)***	0.019 (5.30)***	0.026 (6.92)***	0.018 (5.81)***	0.023 (6.80)***	0.010 (4.39)***	0.013 (4.49)***	0.011 (4.90)***	0.013 (4.66)***
β_2^+	0.002 (0.63)	-0.003 (-0.46)	0.000 (0.11)	0.000 (0.13)	-0.001 (-0.40)	0.002 (0.55)	-0.002 (-0.48)	0.002 (0.61)	-0.001 (-0.26)	-0.000 (-0.07)	-0.002 (-0.72)	-0.000 (-0.03)
β_2^-	-0.002 (-0.64)	0.011 (2.10)**	-0.003 (-0.91)	0.002 (0.48)	-0.003 (-1.09)	0.001 (0.18)	-0.005 (-1.79)*	-0.001 (-0.39)	-0.003 (-1.41)	0.000 (0.04)	-0.003 (-1.68)*	0.002 (0.85)
R^2	0.029	0.206	0.284	0.339	0.260	0.382	0.300	0.373	0.198	0.204	0.236	0.230
Hypothesis 1	0.625		0.802		0.828		1.027		0.265		0.416	
Hypothesis 2	4.625**		0.185		4.564**		1.705		1.159		0.421	
Hypothesis 3	3.669**		1.103		0.131		0.536		1.053		1.320	
Hypothesis 4	4.382**		1.914		1.884		1.515		1.601		3.855**	

Note. See the notes in Table I (for Panel A) and Table VIII (for Panel B).

*Significance at 10%.

**Significance at 5%.

***Significance at 1%.

(Glosten & Milgrom, 1985). Because there is generally no leakage of public information before monetary policy changes are made, and announcements are quickly disseminated into the market, asymmetry may arise not because market makers and traders do not receive the same information, but because traders might have different capacity in processing the information. A similar argument has also been made in Green (2004) on the trading in the bonds market.

CONCLUSIONS

This study examines how the monetary policy announcements affect the two equity ETFs, the S&P 500 SPY fund and the S&P 400 MDY fund. It explores whether the effects of monetary policy surprises are asymmetric in the framework of a two-factor model. The results show that not only surprises in the federal funds rate target but also surprises in the U.S. Fed's future monetary policy directions can exert an impact on the market. In particular, within the first 5 minutes, an unanticipated 25-basis-point cut in the federal funds rate target is associated with about a 2.3% increase in the SPY and a 1.9% increase in the MDY price. However, the cumulative impact for the first 45 minutes only suggests a rise of 1.2% (or 1.6%) in the SPY (or MDY). Furthermore, Bernanke and Kuttner (2005) (using daily data) and Gurkaynak et al. (2005) (using 30-minute data) find that an unanticipated 25-basis-point cut in the federal funds rate target is associated with about a 1% increase in the broad stock market index. Hence, there appears to be some overreaction of the SPY to unanticipated changes in the federal funds rate target in the first 5 minutes' trading. In addition, an unanticipated 25-basis-point decline (or increase) in the four-quarter-ahead eurodollar futures rate is associated with a rise (or decline) of 0.71% (0.40%) in the S&P 500 (S&P 400) ETF over the first 45 minutes.

Particularly, the impact of surprises in the federal funds rate target on the ETFs comes mostly from the negative surprises whereas the positive surprises generally do not have statistically significant effects. This is consistent with the findings of Thorbecke (1997) that expansionary policy increases ex-post stock returns. There is also some evidence that during the period of monetary policy tightening, the market reacts more toward surprises in future 1-year-ahead rate changes, at least during the first 5 minutes' trading. Further evidence from the asymmetric two-factor models suggests that the two ETFs also react asymmetrically to different sizes of the federal funds rate target surprises.

Among many possible directions for future work, of particular interest is why the equity ETFs react asymmetrically to surprise cuts in the federal funds rate target. Another area for future research is the role of order flow in the price formation process. Recent papers by Brandt and Kavajecz (2004) and Green (2004) have documented the informational role of order flow following many macroeconomic news announcements. It would also be interesting to exploit the information in order flow and other liquidity measures to help shed more light on the price discovery process after the monetary policy announcements.

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