THE INFORMATIONAL ROLE OF OPTIONS MARKETS: EVIDENCE FROM FOMC ANNOUNCEMENTS

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Recommended Citation:
Du, B., Fung, S. and Loveland, R., 2018. The Informational Role of Options Markets: Evidence from FOMC Announcements. *Journal of Banking & Finance*., 92, pp.237-256.

Abstract

This paper examines the informational role of equity options trading around Federal Open Market Committee (FOMC) announcements. We find that information contained in option trades prior to FOMC rate change announcements, measured as implied volatility spread, predicts bank stock returns to a greater degree than does volatility spread prior to non-meeting days. We examine U.S. banks due to their interest rate sensitivity, however, we also show that return predictability around rate changes is reliably stronger in all firms, across all industries that are more interest rate sensitive. We find that return predictability is primarily driven by surprise changes in interest rates that occur during meetings with high degrees of information asymmetry. Finally, we document that volatility spread impounds information about FOMC meetings before that information is reflected in stock prices; this effect is significantly greater during surprise events, suggesting that the option market is an important source of informed trading.

Keywords: Options trading; Implied volatility; Federal funds rate; Information efficiency; Banking

JEL Classifications: G14; G20; G21; G28

We thank seminar participants at California State University, East Bay and conference participants at the 2017 Western Economic Association International, 2017 Eastern Finance Association and 2017 World Finance Conference meetings for helpful comments. We gratefully acknowledge the valuable comments of the journal editor (Geert Bakaert), an associate editor, and an anonymous referee. Fung gratefully acknowledges the support of the Jack and Susan Acosta Professorship at California State University, East Bay.

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1. Introduction

The timely incorporation of information into asset prices is an elementary topic in the study of finance. While it is understood that in markets with no frictions, options are considered to be redundant securities, the starting point of this paper recognizes that option markets provide a platform for informed trading and that option trades contain significant information about future stock returns (Pan and Poteshman, 2006; Cremers and Weinbaum, 2010; An, Ang, Bali, and Cakici, 2014; and Ge, Lin, and Pearson, 2016). [1]

The purpose of this study is to examine the informational role of bank equity options trading around macroeconomic news events such as the Federal Reserve's Federal Open Market Committee (FOMC) meetings. In doing so, we extend the literature documenting economically and statistically significant information about future stock returns in options trades. Previous studies find evidence of stock return predictability from options trading (as measured by option implied volatility (IV) spread and/or IV skew) around analyst-related events (Lung and Xu, 2014; Hayunga and Lung, 2014; and Lin and Lu, 2015) and corporate announcements such as earnings (Jin, Livnat, and Zhang, 2012; and Atilgan, 2014), merger and acquisitions (Chan, Ge, and Lin, 2015), and stock splits (Gharghori, Maberly, and Nguyen, 2017). We examine a macro-level event to determine if options trades contain similarly significant information about future stock returns when the event provides information relevant to all firms, not just idiosyncratic information relevant only to the underlying stock.

The joint examination of FOMC meetings and bank stock returns offers a particularly attractive setting to examine informed trading in option markets for two important reasons. First, although FOMC meetings and federal funds rate changes have wide-ranging implications for the

[1] In theory, option markets can provide a platform to trade on new information by providing higher implicit leverage and lower trading costs (Black, 1975) and mitigating short-sale costs and constraints (Diamond and Verrecchia, 1987).

broader market, banks are considered by extant literature to be particularly sensitive to interest rate changes because of the substantial differences in the maturity composition of their assets and liabilities.[2] Hence, any shift in the level or slope of the yield curve will have significant consequences for profitability and stock returns (Flannery and James, 1984; Fraser, Madura and Weigand, 2002; Saunders and Cornett, 2017). This suggests that there should be substantial excess returns for acquiring or interpreting private information associated with rate-related macroeconomic events for firms in this industry. Informed investors with accurate forecasts of the magnitude or timing of future rate changes choose to trade in option markets because it provides operational advantages such as higher implicit leverage and lower trading costs (Black, 1975). This excess demand will consequently affect call and put prices asymmetrically, resulting in a widening of the IV spread.

Second, the nature of FOMC announcements allows for relatively clean characterizations of surprise vs. non-surprise events. Quantifying the level of information asymmetry inherent in an event is important because it enables powerful tests of the previous finding that greater information asymmetry produces greater degrees of return predictability (Cremers and Weinbaum, 2010). We classify surprise and non-surprise events using two separate definitions. In the first definition, we classify surprise events as those from unscheduled meetings which are held via conference calls. While there are eight regularly scheduled FOMC meetings per year, the FOMC may also hold these unscheduled meetings as deemed necessary to review economic and financial developments.

In the second definition, we construct a measure for the unexpected rate change based on the methodology of Kuttner (2001) and Bernanke and Kuttner (2005). We then identify surprise

[2] The nominal contracting hypothesis asserts that interest rate shocks will affect the value of nominal contracts more than the value of real contracts. Because banks have a larger relative proportion of nominal assets compared to non-banks, they are more prone to interest rate risk (French, Ruback, and Schwert, 1983; and Flannery and James, 1984).

(non-surprise) events as ones in which the absolute value of unexpected change in the federal funds rate is greater (less) than 12.5 bps, similar to Bernile, Hu, and Tang (2016). These classification schemes allow for the differentiation between noise trading (from speculators or hedgers) in expected rate changes and truly informed trading in surprise changes where information asymmetry is generally greater (Hayunga and Lung, 2014).

Our study examines 121 FOMC meetings, comprised of regularly scheduled meetings and unscheduled conference calls, from 1996 to 2008. We focus primarily on IV spread (defined as the weighted difference in implied volatilities between call and put options with the same strike price and maturity) as this measure has been shown to forecast expectations about future stock returns and convey information in option trades (Cremers and Weinbaum, 2010; Xing, Zhang, and Zhao, 2010; and An, Ang, Bali, and Cakici, 2014). If some informed investors trade in options before that information is reflected in the underlying stocks, we should expect deviations from put-call parity in the direction of informed investors' private information (Easley, O'Hara, and Srinivas, 1998).

We show that option price deviations from put-call parity (as measured by IV spread) prior to federal funds rate change announcements predict bank stock returns to a greater degree than do IV spreads prior to non-meeting days. On FOMC meeting days, a hedge portfolio based on IV spread quintiles produces an average one-day return of 29.8 bps and a risk-adjusted return of 38.9 bps. On non-meeting days, a similar hedge portfolio produces an average one-day return of 28.8 bps and a risk-adjusted return of 28.6 bps. The difference in raw (risk-adjusted) returns between meeting days and non-meeting days is significant at the 0.1% (1%) level. Regression analysis using pooled meeting and non-meeting day returns confirms the significant difference in returns.

More importantly, we also find evidence that return predictability associated with FOMC meetings is driven primarily by surprise changes in interest rates. When we compare regularly

scheduled meetings with unscheduled conference call meetings, we find that return predictability is significantly greater on conference call meeting days than on regularly scheduled meeting days. The difference in returns is economically meaningful; risk-adjusted hedge portfolio returns are 28.0 bps greater on conference call days than on regular meeting days. When we compare surprise rate changes (those beyond the threshold of a ±12.5 bps unexpected change in the federal funds rate) with non-surprise rate changes, we find that return predictability is significantly greater for surprise rate changes than for non-surprise rate changes. The difference in returns is even more economically meaningful for this definition of surprise; risk-adjusted hedge portfolio returns are 78.6 bps greater for surprise rate changes than for non-surprise changes. Furthermore, we find that return predictability is greatest during the sub-period with the highest degree of information asymmetry (2003 to 2008), further affirming the link between return predictability and information asymmetry. These results are consistent with past studies that show that options trading activities often cluster around events with high degrees of information asymmetry (e.g., Cao and Ou-Yang, 2009).

In addition to the findings on return predictability, we also provide evidence of enhanced information flows from the option market to the stock market, conditional on an FOMC meeting. This evidence helps substantiate the relation between information flows and informed trading and provides additional evidence in support of our finding of greater return predictability during FOMC rate announcements. We follow Archarya and Johnson (2007) in the use of a two-stage regression analysis to quantify information flows from the options market to the stock market. Results show that IV spread impounds information about FOMC meetings before that information is reflected in stock prices, suggesting that the option market is an important source of informed trading. We also show that contribution of information from IV spread to the stock market is significantly greater during surprise events. Collectively, test results presented in this paper are

consistent with informed trading in option market during FOMC meetings and provide evidence that these option trades produce informative signals that predict subsequent bank stock returns.

To demonstrate the external validity of our banking industry experiment, we test return predictability for all firms, regardless of industry. We find that return predictability around federal fund rate change announcements is reliably stronger in firms that are more interest rate sensitive. Our results demonstrate that option trading during FOMC announcements has an informational role not just for banks, but for all interest rate sensitive firms. To support our main results, we perform further analysis and robustness tests. Additional analysis reveals that risk-adjusted hedge portfolio returns are significantly greater on FOMC meeting days than on banks' earnings announcement days. Robustness tests show that the return predictability observed on FOMC announcement days is not driven by volatility skewness and that tail risk on meeting dates is not significantly different from that on non-meeting trading days.

This study contributes to the existing literature on the informational effects of option implied volatility. Our findings demonstrate that the options market has an informational role that reaches beyond firm-level news to include macroeconomic news events such as FOMC meetings. Our study also provides new evidence regarding cross-sectional variation in the effect of options-related information on stock returns during macroeconomic events. Compared to Cremers and Weibaum (2010), who find stock return predictability in a general setting without specific information events, this study shows that stock return predictability related to IV spread is significantly greater during macroeconomic events such as FOMC announcements than it is on days with no information events.

This study is also related to work by Bernile, Hu, and Tang (2016) that uses intraday data to find evidence consistent with informed trading during embargo lockup periods for FOMC scheduled announcements (defined as the 20 minutes prior to the FOMC announcement).

However, Bernile, Hu, and Tang (2016) find no evidence of informed trading in index futures prior to the *start of* embargo periods. In contrast, this study documents evidence of informed trading in the equity options market at the daily interval suggesting that the mechanism for informed trading in this study is not attributable to embargo agreements. In related work, Lucca and Moench (2015) document significant abnormal returns on the S&P500 index prior to FOMC announcements (measured from 2:00 p.m. the day before scheduled FOMC announcements to 2:00 p.m. on the announcement day; policy announcements are typically released at, or around, 2:15 p.m). They conclude that this unconditional excess return is not directly related to the actual FOMC monetary policy decision. Our paper differs in several important ways. First, we measure realized returns from the start to the end of the announcement day, thus we capture the effect of the policy decision. More importantly, we find significant evidence of information revelation in the options market the day prior to the announcement, such that it significantly predicts returns in the cross-section once the decision is incorporated into stock prices following the announcement.

This study also contributes to the extensive body of literature that examines the impact of FOMC monetary policy decisions on stock returns (Bernanke and Kuttner, 2005; and Lucca and Moench, 2015), stock volatility (Bomfim, 2003; and Chuliá, Martens, and van Dijk, 2010), and option implied volatility (Bali and Hovakimian, 2009; Krieger, Mauck, and Chen, 2012; Gospodinov and Jamali, 2012; and Chen and Clements, 2007). While past studies, such as Nikkinen and Sahlström (2004) and Vähämaa and Äijö (2011), focus on the association between monetary policy and market-wide option implied volatility (VIX), our study examines the relation between FOMC meetings and firm-level heterogeneous option implied volatilities.

The remainder of the paper is organized as follows. Section 2 discusses the research design and hypotheses. Section 3 examines federal fund rate changes and bank stock returns and explains the construction of our measure of unanticipated federal funds rate changes. Section 4 discusses

the data, sample, and variable construction. The empirical results are presented in Sections 5 and 6. Section 7 provides tests of external validity and further analysis. Section 8 concludes.

2. Research design and hypotheses development

Unlike corporate announcements, which convey firm-specific idiosyncratic information, macroeconomic announcements represent significant market-wide news that is informationally relevant to a broad cross-section of firms. Past studies on the effects of macroeconomic news announcements focus primarily on stock and bond markets. (see, e.g., Balduzzi, Elton, and Green, 2001; Green, 2004; Kurov, Sancetta, Strasser, and Wolfe, 2015; and Chordia, Green, and Kottimukkalur, 2015). The extant literature that examines FOMC meetings as the macroeconomic event of study looks at informed trading in the stock market prior to FOMC announcements (Lucca and Moench, 2015), index futures market (Bernile, Hu, and Tang, 2016), and federal funds futures market (Emmons, Lakdawala, and Neely, 2006). However, while the options market is considered a venue for informed trading (Easley, O'Hara, and Srinivas, 1998), the examination of option market trading around macroeconomic news events has received relatively little attention in the extant literature. Motivated by this literature gap, we develop hypotheses in this section to investigate stock return predictability around FOMC meeting announcements.

We focus primarily on the banking industry because the interest-rate sensitive nature of its business model makes the industry particularly sensitive to interest rate changes (French, Ruback, and Schwert, 1983 and Flannery and James, 1984). For this reason, then, FOMC meetings are considered to be particularly relevant events for banks. The focus on this single industry also helps to control for unobserved firm heterogeneity and industry-level effects that may confound the empirical relationship between options trading and stock returns.

2.1. *Framework of empirical analysis*

We construct our research design to examine the relation between informed options trading and subsequent stock returns. Figure 1 presents the framework of our empirical analysis. Investors' information acquisition, and their expectations about federal funds rate changes, are reflected in option trades prior to FOMC meetings, as measured by the implied volatility spread ($VS_{i,t\text{-}1}$). We examine whether implied volatility spread $VS_{i,t\text{-}1}$ (A in Figure 1), measured *before* the FOMC announcement, can predict future stock returns $Return_{i,t+n}$ (B in Figure 1). We model the relation between implied volatility spread, $VS_{i,t\text{-}1}$, and future stock returns, $Return_{i,t+n}$, during federal funds rate change announcement as follows [3]:

$$Return_{i,t+n} = f(VS_{i,t\text{-}1}) + \varepsilon_{i,t+n} \tag{1}$$

where t denotes the date of the federal funds rate change announcement; i denotes firm i in the banking industry setting; and $\varepsilon_{i,t+n}$ denotes residual returns that are orthogonal to information contained in implied volatility spread.

<Insert Figure 1 about here>

2.2. *Hypotheses*

We develop two testable hypotheses to examine informed trading in the options market during FOMC announcements. We build on previous findings that *i*) option prices, due to informed trading in the options market, contain information not yet contained in stock prices (Cremers and Weinbaum, 2010), and *ii*) that options trading often clusters around events with high degrees of information asymmetry and disagreements among investors (Cao and Ou-Yang, 2009). As such, the impact on underlying markets of information contained in option prices should be most pronounced during informationally asymmetric events.

[3] We note that our design is not plagued with issues of nonsynchronous data. FOMC announcements are typically released at 2:15 pm EST, prior to the close of the stock market on day t.

A testable prediction, as synthesized from the discussions above, is:

Hypothesis #1: The degree of stock return predictability associated with IV spread is greater on FOMC meeting days than on non-meeting days.

In our analysis of return predictability it is important to distinguish between expected and unexpected events (Cao and Ou-Yang, 2009; and Hayunga and Lung, 2014). Kuttner (2001) shows that the impact of monetary policy changes on stock returns is greater for unanticipated changes. Bernile, Hu, and Tang (2016) suggest that the difference between the market's expectation of news and the actual announced news represents the information that market prices should impound upon announcement. If the market's expectation is the same as the announced news, then market prices should not change during announcement. Hence, the magnitude of the surprise should be directly correlated with the value of possessing the private information. The degree of surprise, then, will be directly associated with the magnitude of informed trading because the equity price innovation upon announcement will outweigh transaction costs.

We provide two definitions to infer whether the FOMC meeting is considered a surprise (or, unexpected) event or a non-surprise (or, expected) event. In the first classification, unscheduled FOMC conference calls (which are held as necessary) are deemed to be surprise events while scheduled FOMC meetings (which are held eight times per year) are deemed to be non-surprise events. Note that conference calls are similar to regularly scheduled meetings in that they may also result in an actual change in the target rate. In the second classification, we follow the approach used by Bernile, Hu, and Tang (2016): for each FOMC meeting, we use federal funds futures to measure unexpected changes in the federal funds target rate according to the methodology in Kuttner (2001). We then classify an FOMC meeting as a surprise event if the absolute value of the unexpected change in the target rate is greater than 12.5 bps; we classify the

meeting as a non-surprise event if the absolute value of the unexpected change in the target rate is less than 12.5 bps.

A testable prediction, as synthesized from the discussions above, is:

Hypothesis #2: The degree of stock return predictability associated with IV spread is greater during surprise announcements than during non-surprise announcements.

3. FOMC announcements, stock returns, and unexpected federal funds rate changes

Figure 2 presents a time series plot of nominal federal funds rate changes compared to the median stock return on announcement day for our sample of banks during the sample period 1996 to 2008. The federal funds rate increased several times, in 25 and 50 bps increments, during the economic boom of the late 1990s and was subsequently lowered several times, in 25 bps increments, during the short recession of the early 2000s. The rate increased steadily in consecutive 25 bps hikes during the mid-2000s housing boom and then dropped dramatically, in 25 to 75 bps increments, before and during the financial crisis.

<Insert Figure 2 about here>

Figure 3 compares the magnitude of federal funds rate changes to the magnitude of same day median bank stock returns. A 75 bps decrease in the rate results in a median daily return of almost 6%; 50 bps and 25 bps decreases result in much smaller returns of 35 and 13 bps, respectively. An announcement of no rate change results in a positive return of 35 bps. An announcement of a 25 bps increase in the rate produces a 4 bps increase in same day median bank stock returns; a 50 bps increase results in a 72 bps decrease in returns. Thus, evidence to this point demonstrates that, for the average bank in the sample, rate decreases, no rate changes, and small rate increases are essentially "good news" for bank stocks: the median daily return for these events

is positive. Conversely, large rate increases may be considered "bad news" for bank stocks as they result in daily losses.

<Insert Figure 3 about here>

Past studies show that anticipated changes in the federal funds rate are largely incorporated into stock prices prior to the announcement of the rate change whereas unanticipated policy actions are not, and thus produce the greater stock price response (e.g. Bernanke and Kuttner, 2005). To distinguish between anticipated and unanticipated actions of the Federal Reserve, we utilize the approach employed by Kuttner (2001) to measure unexpected changes in the federal funds target rate using federal funds futures. This methodology is widely used in the subsequent literature covering the effects of FOMC announcements (Bernanke and Kuttner, 2005; Hamilton, 2009; and Chuliá, Martens, and van Dijk, 2010). The unexpected element of changes in the federal funds target rate target is extracted from daily changes on day *d* in the implied target rate of the current-month federal funds futures contract in month *m* by:

$$\Delta\phi^{u} = \frac{D}{D-d}\left(f_{m,d}^{0} - f_{m,d-1}^{0}\right) \tag{2}$$

where $\Delta\phi^{u}$ is the unexpected target rate change, D the number of days in the month, and $f_{m,d}^{0}$ is the current month futures rate. Since federal funds futures contract settlement prices are based on monthly averages, Kuttner (2001) notes that the measure must be scaled up by a factor relating to the number of days in a month.

<Insert Table 1 about here>

Table 1 reports summary statistics of federal funds rate changes on FOMC meeting and non-meeting days. Panel A reports that of the 121 FOMC meetings from 1996 to 2008, 103 are regularly scheduled and 18 are conference calls. The mean unexpected rate change on conference call days (−12 bps) is substantially greater in magnitude than the unexpected rate change on

scheduled meeting days (−1 bps). Nine of the scheduled meetings are classified as surprise rate changes while five of the conference calls are classified as such. Panel B reports on the sub-period 1996 to 2002. Of the five conference calls during the period, we classify three as surprise rate changes; we find that three of the regularly schedule meetings are also surprise rate changes. Panel C reports that during the 2003 to 2008 sub-period, two of the 13 conference calls are surprise rate changes, while six of the regularly schedule meetings are also surprise rate changes. Given that our two definitions of surprise are not mutually exclusive, there are thus eight unique surprise events in the 1996 to 2002 subsample period, while in the 2003 to 2008 subsample period there are 19 unique surprise events, more than twice the number during the earlier subsample period.

Panel D reports the FOMC meetings that did not result in a change in the federal funds target rate. The mean unexpected federal funds rate change is −1 bps regardless of meeting. Panels E and F classify the meetings that result in either positive or negative rate changes. Of the five conference calls that resulted in a rate change, all of them were negative rate changes. Finally, Panel G reports statistics for all non-meeting days from 1996 through 2008; the mean unexpected federal funds rate change on non-meeting days is 0 bps.

4. Data, sample, and variable construction

The sample period used for this study is from 1996 to 2008. We end our sample at year-end 2008 because there are no federal fund rate changes from December 2008 to December 2015. More importantly, because the Federal Reserve was up against the zero lower bound created by the near-zero target range for the federal funds rate, they focused monetary action on the long end of the yield curve from 2009 onward. Thus, there were no reasonable expectations for federal

funds rate changes over this period.[4]

We focus on bank holding companies as defined by the Federal Reserve. Daily stock returns are obtained from the Center for Research in Security Prices (CRSP) daily file. Options data is from OptionMetrics. Data for federal funds futures contracts is from Quandl.

We follow Amin, Coval and Seyhun (2004) and Cremers and Weinbaum (2010) in measuring deviations from put-call parity as the difference between put and call implied volatilities. Cremers and Weinbaum (2010) argue that when dealers anticipate a rise in the price of the underlying stock they will set a higher premium for call options. Conversely, when they anticipate a drop in the price of the stock they will set a higher premium for put options. Thus, a negative difference in implied volatilities between call and put options would produce a negative volatility spread; this negative spread should predict negative future returns and vice versa.

The variable volatility spread measures deviations from put-call parity as the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs. More formally, for every day *t* and for every stock *i* with put and call option volume on day *t*, we compute the volatility spread as:

$$VS_{i,t} = \sum_{j=1}^{N_{i,t}} w_{j,t}^{i} \left(IV_{j,t}^{i,call} - IV_{j,t}^{i,put} \right) \tag{3}$$

where *j* refers to the *j*th pair of put and call options and indexes both strike prices and maturities, $w_{j,t}^{i}$ are weights computed as the average open interest in the call and put, $N_{i,t}$ denotes the number of pairs of options on stock *i* on day *t*, and $IV_{j,t}^{i}$ denotes the implied volatility (adjusted for dividends and the possibility of early exercise). To ensure that the options have sufficient liquidity,

[4] In (unreported) robustness tests, we conduct additional analysis for the period 2009 to 2015. Test results show that return predictability is not significantly different from zero for FOMC meetings after 2008. For non-meeting dates, returns for the 2009 to 2015 period are lower than for the 2003 to 2008 period, supporting the finding in Cremers and Weinbaum (2010) that general return predictability decreases over time.

we follow Xing, Zhang, and Zhao (2010) and Jin, Livnat, and Zhang (2012) in computing the implied volatility spread based on option contracts with time to expirations of 10 to 60 days.

To examine the degree of return predictability associated with volatility spreads, we form quintile portfolios based on volatility spreads, rebalance the portfolio the day prior to each FOMC meeting, and examine daily returns for the day of the announcement (Day one) and the day following the announcement (Day two). Quintile 1 contains stocks with low volatility spreads; Quintile 5 contains stocks with high volatility spreads. We then form a hedge portfolio that is long the quintile of high volatility spread stocks and short the quintile of low volatility spread stocks. Stocks are equally weighted within each quintile portfolio.

To ensure that hedge portfolio returns are not driven by cross-sectional differences in risk or firm characteristics, we follow Cremers and Weinbaum (2010) in calculating abnormal returns via a five-factor model. Included in this model are the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. The estimated abnormal return of the hedge portfolio is the constant, α_j, in the following regression:

$$R_{j,t} = \alpha_j + \delta_{1j}MKT_t + \delta_{2j}SMB_t + \delta_{3j}HML_t + \delta_{4j}UMD_t + \delta_{5j}BNK_t + \varepsilon_{j,t} \quad (4)$$

where $R_{j,t}$ is the excess return over the risk-free rate of portfolio j over time t; and MKT_t, SMB_t, HML_t and UMD_t are the excess return on the market portfolio and the return on three long/short portfolios that capture size, book-to-market and momentum effects, respectively; and BNK_t is the value-weighted return on the Banking industry portfolio formed using the Fama-French 48 industry definition.

Table 2 reports descriptive statistics for IV spreads by FOMC meeting. Panel A reports IV spreads as of the close of trading the day prior to all FOMC announcement dates while Panel B reports IV spreads on non-meeting days. Non-meeting days are defined as days outside a three-

day window around each federal funds announcement day. Panel A shows that the mean (median) volatility spread prior to announcement dates over the full sample period is −0.93% (−0.37%). The variability of volatility spreads is considerable: standard deviation for the sample is 4.06%. The reported sample statistics for volatility spreads are consistent with those reported in Cremers and Weinbaum (2010) and Ofek, Richardson, and Whitelaw (2004). By comparison, Cremers and Weinbaum (2010) report mean (median) volatility spread of −0.98% (−0.77%) and standard deviation of 3.97% for all listed equity options for the period 1996 to 2005.

Panel B reports that IV spreads are, on average, slightly narrower and less volatile on non-meeting days. Mean (median) volatility spread is −0.83% (−0.35%) while standard deviation is 3.54%. Thus, while bank stock options have volatility spreads similar to that for the cross-section of stocks economy-wide, an initial examination shows that volatility spreads in connection with FOMC announcement dates are more negative and more volatile, on average, than on non-meeting days.

<Insert Table 2 about here>

5. Portfolio returns sorted by volatility spreads

In this section, we examine whether options trades contain predictive information about future stock returns. We build on insights from the literature that deviations from put-call parity in options on individual stocks may reflect the trading activity of informed investors in the option markets (Cremers and Weinbaum, 2010). To test Hypothesis #1, we investigate whether option trades prior to FOMC meetings, and the resulting impact on option contract implied volatilities, produce information useful in predicting subsequent bank equity values and returns. If deviations from put-call parity contain information about future returns, then we should find a significant difference between the returns on bank equity option contracts with low volatility spreads and bank equity option contracts with high volatility spreads.

5.1 Tests of informed trading around federal funds announcement dates

Table 3 reports daily returns for bank stock portfolios formed based on volatility spreads as of the close of the trading day prior to FOMC meetings. Reported results show that stocks with high volatility spreads have significantly higher next day returns on FOMC announcement days (Day one in Table 3) than do stocks with low volatility spreads. For the full sample in Panel A, the mean return for the hedge portfolio is 29.8 bps (with a *t*-statistic of 2.85), while the five factor-adjusted return is 38.9 bps (with a *t*-statistic of 5.02). Raw and risk-adjusted returns increase monotonically from quintile 1 to quintile 5. Quintile 5, the quintile with the largest spreads, earns a raw return of 68.7 bps and a risk-adjusted return of 29.0 bps, both highly statistically significant. Quintile 1, the quintile with the lowest spreads, earns a raw return of 38.9 bps and a risk-adjusted return of –9.9 bps.

<Insert Table 3 about here>

Panel B presents portfolio returns for the sub-period 1996 to 2002. Day one raw and risk-adjusted returns are similar to those for the full sample; the raw and risk-adjusted returns for the hedge portfolio are lower than those for the full sample. Panel C reports portfolio returns for the sub-period 2003 to 2008. Day one raw and risk-adjusted returns are again similar to those for the full sample. However, the raw and risk-adjusted returns for the hedge portfolio are higher than those for the full sample.

We also examine the persistence of return predictability by measuring daily returns for the same portfolios on the day following announcement date (Day two in Table 3). Panel A reports a moderation of returns, on average, across the quintiles. The risk-adjusted return for the hedge portfolio is 0.3 bps. Moreover, returns display considerable fluctuation across quintiles. Panel B again reports a moderation of returns during the period 1996 to 2002. The risk-adjusted return for the hedge portfolio is –9.0 bps. Returns again fluctuate considerably across quintiles. However,

Panel C reports that Day two risk-adjusted average returns for the period 2003 to 2008 display less moderation. The risk-adjusted return for the hedge portfolio is 8.5 bps. Overall, we find that Day two hedge portfolio raw and risk-adjusted returns are insignificant, indicating that the information contained in volatility spreads is generally short-lived. We examine the drivers of this apparent temporal trend in Day one return predictability in subsequent analysis.

Also reported in Table 3 is the R^2 produced by regressing each quintile's daily return on that quintile's volatility spread. Panel A reports the one-day quintile R^2 for the full sample range from 0.005 to 0.083. R^2 figures are roughly similar in pattern and magnitude for Day two. However, Panel B reports that R^2 figures are higher, on average, for Day one than for Day two suggesting that volatility spread does a better job explaining day ahead return than two-day ahead return during the period 1996 to 2002. Panel C reports greater average magnitude and dispersion in Day one quintile R^2 than for the full sample; R^2 values during the period 2003 to 2008 range from 0.007 to 0.153. However, the R^2 figures are roughly similar in pattern and magnitude for Day two.

Overall, the initial results presented in Table 3 suggest that implied volatility spread just before FOMC announcements does predict subsequent bank stock returns. Test results also suggest that return predictability increased over the sample period, a finding that contradicts the evidence in Cremers and Weinbaum (2010) that return predictability diminished over time for the full cross-section of stocks listed on CRSP.

5.2 Tests of informed trading on non-meeting days

To place the foregoing results in context, we next examine returns on non-meeting days. We exclude a three-day window around each federal funds announcement day: the days on which there is a FOMC meeting, as well as the trading days immediately prior and after. We again form quintile portfolios based on volatility spread and rebalance the portfolio at the end of each trading

day prior to the day we measure returns.

Table 4 reports daily returns for bank stock portfolios on non-meeting days. Panel A confirms the finding that stocks with high volatility spreads have significantly higher next day returns than do stocks with low volatility spreads. However, average raw and risk-adjusted returns are significantly lower as compared to those on announcement days. Quintile 1 earns a risk-adjusted return of −14.0 bps while Quintile 5 earns a risk-adjusted return of 14.6 bps, both highly statistically significant. Raw and risk-adjusted returns increase monotonically from quintile 1 to quintile 5. The risk-adjusted return for the hedge portfolio is 28.6 bps. These results are consistent with Cremers and Weinbaum (2010) who find next day raw and risk-adjusted, value-weighted returns of 38.7 bps and 37.9 bps, respectively. They also find significantly positive returns for quintile portfolios with the highest volatility spread stocks.

<Insert Table 4 about here>

Returns reported in Panels B and C show that the degree of return predictability decreases over the sample period. The risk-adjusted return of the hedge portfolio drops from 35.0 bps during the 1996 to 2002 period to 21.3 bps during the 2003 to 2008 period. Again, this result is consistent with findings reported in Cremers and Weinbaum (2010) that overnight risk-adjusted return drops from 39 bps during the first half of their sample period to 23 bps over the latter half of their sample period. Further, the R^2 values reported for non-meeting days in Panel A are lower in magnitude, on average, than for the Day one returns on meeting days reported in Table 3.

Panel D reports the results of a *t*-test that mean risk-adjusted returns on FOMC meeting days are greater than on non-meeting days. The difference in raw returns is 1.00 bps (with a *t*-statistic of 9.87, significant at the 0.1% level, one-tailed). The difference in hedge portfolio alphas is 10.28 bps (with a *t*-statistic of 2.62, significant at the 1% level, one-tailed), suggesting that the risk-adjusted hedge portfolio return is 36% larger for meeting days than for non-meeting days.

Taken together, the results in Tables 3 and 4 reveal that the magnitude of return predictability is substantially lower on non-meeting days than on FOMC meeting days and exhibits a decreasing trend over time rather than the increasing trend seen on announcement days. The results also reveal that this effect is driven by the 2003 to 2008 subsample period. We examine sub-period results in more detail in the following section. Overall, the findings in Tables 3 and 4 are consistent with Hypothesis #1 that the power of implied volatility spread to predict next day bank stock returns is greater during FOMC meetings than on non-meeting days.

5.3 Investigating drivers of return predictability

We next investigate potential drivers of the return predictability in announcement day portfolio returns. As described in section 2.3, we use our two definitions of surprise to capture any asymmetric information effects. If rate change announcements are a surprise we would expect greater information asymmetry over these dates and, thus, a greater stock price reaction to the unexpected new information, on average. Table 5 presents results of tests that examine return predictability for surprise meetings (conference calls); Table 6 presents results of tests that examine return predictability for surprise rate changes (those in which the absolute value of unexpected changes in the federal funds rate is greater than 12.5 bps).

Panel A of Table 5 reports on the subsample of FOMC meetings that are unannounced to the public *ex-ante*. Such meetings are necessitated by quickly changing economic conditions that the Federal Reserve feels obligated to respond to without waiting for the next regularly scheduled Board meeting. Panel B of Table 5 reports on announcements made as a result of regularly scheduled FOMC meetings; these meetings make up the balance of the sample.

<Insert Table 5 about here>

Panel A reports that average risk-adjusted returns for bank stocks around conference call announcement days are comparatively higher than average announcement day risk-adjusted

returns reported in Table 3 for the full sample. Quintile 1 earns a positive risk-adjusted return of 5.0 bps while Quintile 5 earns a risk-adjusted return of 67.6 bps; the risk-adjusted return for the hedge portfolio is 62.6 bps. Returns in this sample show some persistence; the risk-adjusted return of the Day two hedge portfolio is 9.6 bps, higher than that of the full sample.

Average returns for regularly scheduled meetings, reported in Panel B, are lower than those on conference call days. Stocks with high volatility spreads again have significantly higher next day returns than do stocks with low volatility spreads. Risk-adjusted returns increase from −11.1 bps in Quintile 1 to 23.5 bps in Quintile 5. The risk-adjusted return for the hedge portfolio is 34.6 bps. As with the full sample, returns for regular meetings show considerable moderation. The magnitude of Day two risk-adjusted return is much lower across all quintiles; the risk-adjusted return for the hedge portfolio is –0.9 bps. Returns show no discernable pattern across quintiles.

In addition to greater risk-adjusted returns, the Day one R^2 reported for conference calls announcement days is much higher than for the full sample reported in Table 3, particularly in Quintiles 1 through 3, where the R^2 ranges from 0.143 to 0.157. Day two R^2 is considerably lower, on average. Day one R^2 for regularly scheduled meetings is much lower than for conference calls announcement days. Day one and Day two R^2 are roughly equivalent, on average.

Panel C reports the results of a *t*-test that mean returns on conference call announcement days are greater than those on regularly scheduled meetings days. The difference in risk-adjusted portfolio returns is 28.01 bps, significant at the 5% level (one-tailed). However, raw returns on conference call announcement days are not significantly greater than raw returns on regularly scheduled meetings day. Untabulated results from *t*-tests also show that mean risk-adjusted and raw returns on conference call announcement days are greater than on non-meeting days, significant at the 5% and 10% levels (one-tailed), respectively.

To further examine whether greater information asymmetry produces a greater degree of

return predictability, we next test our second definition of surprise: meeting days in which the absolute value of the unexpected change in the target rate is greater than the 12.5 bps threshold. Table 6 reports daily returns for bank stock portfolios for surprise and non-surprise rate changes. The risk-adjusted return of the hedge portfolio for surprise rate changes, reported in Panel A, is 112.1 bps. This return is much larger than the 33.5 bps risk-adjusted return for non-surprise rate changes, reported in Panel B. Returns again show little persistence from Day one to Day two.

<Insert Table 6 about here>

Panel C reports that the difference in risk-adjusted portfolio returns between surprise and non-surprise rate changes is 78.55 bps. A one-tailed *t*-test produces a *t*-statistic of 3.90, significant at the 0.1% level. The difference in nominal portfolio returns is 26.59 bps. A one-tailed *t*-test is also significant at the 0.1% level (one-tailed). Untabulated difference tests show that mean risk-adjusted and raw returns for surprise changes are greater than risk-adjusted returns on non-meeting days, significant at the 0.1% level (one-tailed).

Collectively, test results reported in Tables 5 and 6 are consistent with Hypothesis #2 that the degree of return predictability is greater during surprise rate changes than during non-surprise rate changes. These findings also help to explain the difference in return predictability between sub-periods. Tables 3 and 4 (Panels B and C) report that returns are significantly greater (at the 0.1% level) on FOMC meeting days than on non-meeting days during the sub-period 2003 to 2008, but not during the sub-period 1996 to 2002. However, the 2003 to 2008 sub-period contains more than twice the number of unique surprise events than does the 1996 to 2002 sub-period (19 vs. 8). If return predictability is driven by information events with high degrees of information asymmetry, we expect to find the greatest return predictability in the period with the highest information asymmetry. Indeed, we find that return predictability is greatest during the sub-period 2003 to 2008, the period with more informationally asymmetric events.

To further investigate the apparent temporal variation in return predictability, we divide our sample into the sub-period 1996 to 2000 and the sub-period 2001 to 2008. This alternate definition of sub-period more neatly dichotomizes surprise events by sub-period; the sub-period 2001 to 2008 contains 16 conference calls and 11 surprise changes, vs. 2 and 3, respectively, for the sub-period 1996 to 2000. Overall, the results provide further support that the degree of return predictability is greater during periods with more informationally asymmetric events. On meeting days during the 1996 to 2000 sub-period, the hedge portfolio generates a risk-adjusted return of 43.70 bps, as compared to a risk-adjusted return of 38.1 during non-meeting days; the difference is not statistically significant. However, during the 2001 to 2008 sub-period the hedge portfolio generates a risk-adjusted return of 44.30 bps, significantly greater (at the 0.1% level) than the 22.60 bps risk-adjusted return during non-meeting days.

6. Further tests of informed trading around federal funds announcement dates

6.1 Regression analysis

As a further empirical test of our hypotheses, we next use regression analysis to examine the strength of the return predictability effect by controlling for known determinants of bank stock returns on FOMC announcement days. We use the following regression specification:

$$R_{i,t} = \beta_{0i} + \beta_{1i}\Delta ff_t + \beta_{2i}\Delta ff_t^u + \beta_{3i}IVSpread_{i,t-1} + \beta_{4i}MonetaryCycle_t$$

$$+ \beta_{5i}IR\ Sensitivity_{i,t} + \beta_{6i}Meeting_t + \beta_{7i}Meeting_t \times IVSpread_{i,t-1} + \varepsilon_t \quad (5)$$

where $R_{i,t}$ is the daily return of bank i on day t; Δff_t is the announced change in the federal funds target rate; Δff_t^u is the unexpected change in the target rate, as calculated by Kuttner's (2001) method in equation 2 and $IVSpread_{i,t-1}$ is the volatility spread for bank i on day t–1, as calculated

by equation 3. The primary variable of interest, $Meeting_t \times IVSpread_{i,t-1}$, is an interaction variable that captures the effect of volatility spread on FOMC meetings days; $Meeting_t$ is a dummy variable that equals one on FOMC meeting days, zero otherwise. If volatility spread has a stronger predictive effect on FOMC meeting days, or on FOMC meetings days with surprise rate changes, we should find a positive and significant coefficient for the interaction variable.

In addition to the variables constructed in Section 4, an indicator variable, $MonetaryCycle_t$, is used to measure the impact of monetary tightening cycles on bank stock returns. Evidence in the literature shows that market responses to interest rate changes vary in magnitude and direction depending upon the monetary tightening/loosening regime undertaken by the Federal Reserve at the time of the rate change. Following Adrian, Estrella, and Shin (2010), the variable monetary cycle takes on a value of 1 for each bank/day observation during a period of rising federal funds rates or 0 for each bank/day observation during a period of falling federal funds rates.

In addition, the banking literature provides evidence that short-run bank returns also vary cross-sectionally by the degree of sensitivity to interest rate changes (English, Heuvel, and Zakrajsek, 2012). We quantify interest rate risk with respect to individual bank stock returns following the approach of Demsetz and Strahan (1997). Demsetz and Strahan (1997) utilize a multi-factor market model, with includes additional risk factors that commonly affect bank returns, to quantify the effect of market interest rate changes on bank stock returns. Thus, our measure of bank-specific interest rate sensitivity, $IR\ Sensitivity_{i,t}$, is the coefficient on $Yield_t$[5] from the estimation of the Demsetz and Strahan (1997) model using weekly data over our sample period 1996 to 2008. Variables definitions are provided in Appendix A.

[5] $Yield_t$ is the weekly holding period return on three-month Treasury Bills using the price of the bill at the close of trading every Friday; it captures changes in short term rates.

To control for unobserved firm heterogeneity, we estimate panel regressions with firm fixed-effects. Following the approach favored by Petersen (2009), regressions also incorporate time fixed-effects (using year dummies), while standard errors are corrected for clustering at the bank level. To reduce the influence of outliers, all variables are winsorized at the 1% and 99% level.

Table 7 reports regression results. Models 1, 2, and 3 examine return predictability on FOMC meeting days, Model 4 on non-meeting days, and Models 5, 6, and 7 examine the pooled sample of meeting and non-meeting days over the entire sample period. Model 1 reports that increases in the nominal federal funds rate and unexpected increases in the federal funds rate have negative and significant effects on bank stock returns. The primary variable of interest, volatility spread, has a positive and highly significant coefficient. The estimated coefficient for the control variable monetary cycle is positive and significant, indicating that rate increases during monetary tightening cycles have a greater effect on bank stock returns than increases during monetary loosening cycles. The estimated coefficient for the interest rate sensitivity control variable is negative and significant, indicating that bank stocks with higher interest rate sensitivity experience greater losses on FOMC meeting days, on average.

<Insert Table 7 about here>

Models 2 and 3 test the effect of implied volatility spread during surprise rate changes. To do so, we construct two different interaction variables using our two definitions of surprise: (Conf call meet × Vol spread) where conference call is a dummy variable that takes on a value of 1 for meetings held as conference calls, zero for regularly scheduled meetings, and a second specification (Surprise change × Vol spread) where surprise is a dummy variable that takes on a value of 1 if the absolute value of unexpected changes in the federal funds rate is greater than 12.5 bps, zero for changes less than 12.5 bps. The estimated coefficient for the interaction variable

(Conf call meet × Vol spread) in Model 2 is insignificant. The estimated coefficient for the interaction variable (Surprise change × Vol spread) in Model 3 is also insignificant. These test results are inconsistent with results from hedge portfolio testing that finds economically and statistically significant differences in returns between regular and surprise meetings.

We next perform the same test on days in which there are no FOMC meetings. We again exclude a three-day window around each federal funds announcement day. By necessity, we exclude the explanatory variable (nominal) fed fund change as there are no changes on non-meeting days. Model 4 reports that the unexpected component of federal funds rate changes has a small, positive and significant effect on bank stock returns. Notably, the sign of the estimated coefficient is the inverse of that found on meeting days. Volatility spread again has a positive and significant estimated coefficient as predicted, however the effect is less than half of the effect on the average announcement day.

Given the evidence that returns, and return predictability, are elevated on FOMC meeting days, we next test the significance of this effect. To do so, we run regressions on pooled data sets containing both meeting and non-meeting days; we utilize the same explanatory variables used in the foregoing regression analyses. For purposes of these tests, the day after the FOMC meetings (Day 2 in the hedge portfolio analysis) is removed. Model 5 reports that increase in the nominal federal funds rate has a negative and significant effect on bank stock returns. Unexpected increase in the federal funds rate has a positive but much less significant effect. Implied volatility spread continues to have a positive and highly significant coefficient.

The variables of interest in this test are the FOMC meeting dummy and the interaction variable (FOMC meeting × Vol spread) where FOMC meeting dummy is a dummy variable for FOMC meetings days. The meeting dummy and the interaction variable both have a positive and highly significant effect on bank stock returns, indicating that return predictability is significantly

higher on FOMC meetings days than on non-meeting days.

Model 6 utilizes the same specification, but tests the difference in return predictability between conference calls and non-meeting days. The estimated coefficient for the interaction variable (Conf call meet × Vol spread) is positive and significant; the conference call dummy is insignificant. This result indicates that the effect of the volatility spread is greater on conference call days. The estimated coefficients for the balance of the variables retain the same sign and significance, with the exception of the unexpected rate change variable, which has an insignificant effect.

Model 7 substitutes the dummy variable surprise and the interaction variable (Surprise change × Vol spread). The estimated coefficients for the surprise dummy and the interaction variable are positive and highly significant. The magnitude of the coefficient for the surprise dummy is less than that of the FOMC meeting dummy in Model 5. The magnitude of the coefficient for the interaction variable is roughly twice that of the FOMC meeting interaction variable in Model 5 and greater than that of conference call interaction variable in Model 6.

Thus, the analysis presented in Table 7 demonstrates that return predictability is significantly greater on FOMC meeting days than on non-meeting days. Estimated coefficients for the volatility spread variable are positive and highly statistically significant in all specifications, however the magnitude of the coefficient on FOMC meeting days is over twice that on non-meeting days. Controlling for unexpected federal funds rate changes, a monetary cycle effect and cross-sectional interest rate sensitivity does not alter the effect of volatility spread on future bank stock returns. This result supports Hypothesis #1.

6.2 Conditional information flow

Given the finding that options trades contain economically and statistically significant information about future stock returns, we next conduct tests to identify the flow of information

from the options market to the stock market. Confirmation of an information transfer from option to stock markets, specific to FOMC rate announcements, would be further confirmation that informed trading in the options market precedes revelation of event-specific information in the stock market. To do so, we first identify the unconditional flow of IV spread innovations from the option to stock markets; we consider these unconditional flows to be typical, or baseline, information flow between the option and stock market. We then identify additional, conditional information flows specifically attributable to FOMC rate announcements.

To identify information flow, we employ a two-stage approach adapted from Hou and Moskowitz (2005), Acharya and Johnson (2007), and Hayunga and Lung (2014). In the first stage, we regress the implied volatility spread on a constant, the past five lags of the IV spread, the contemporaneous stock return, and the past five lags of stock returns for each firm, as follows:

$$\text{IV spread}_{i,t} = \propto_i + \sum_{k=0}^{5} \beta_{i,t-k}\text{return}_{i,t-k} + \sum_{k=1}^{5} \delta_{i,t-k}\,\text{IV spread}_{i,t-k} + \mu_{i,t} \qquad (6)$$

Time-series dependencies and level-dependent dynamics in the implied volatility spread are absorbed in performing this first stage. The residuals, $\mu_{i,t}$, are considered to be the independent arrival of news to the option market that are not attributed to, or influenced by, past information from the stock or option market. These residuals are subsequently used as a measure of option market innovations in the next stage.

In the second stage, we examine the information flow from the option to stock markets conditional on five different definitions of an event: *i*) all FOMC meetings, *ii*) scheduled FOMC meetings, *iii*) non-scheduled conference calls, *iv*) FOMC meetings that are surprise events using the ± 12.5 bps unexpected rate change threshold, and *v*) FOMC meetings that are not surprise events using the ± 12.5 bps unexpected rate change threshold. We utilize a panel specification that

regresses stock returns on the past five lags of stock returns, the past five lags of option market innovations, and the products of a dummy variable with the former two variables:

$$\text{return}_t = a + \sum_{k=1}^{5}[b_k + b_k^D(\text{D})_t](\mu)_{t-k} + \sum_{k=1}^{5}[c_k + c_k^D(\text{D})_t]\text{return}_{t-k} + \varepsilon_t \quad (7)$$

where D is equal to unity in the five days prior to an event, zero otherwise, μ is the option market innovation obtained from the estimated residuals in Equation (6), $\sum_{k=1}^{5} b_k$ is the unconditional information flow from the options markets, $\sum_{k=1}^{5} b_k^D$ is the conditional information flow from the option market on the FOMC meeting event, $\sum_{k=1}^{5} c_k$ is the unconditional information content of past stock returns, and $\sum_{k=1}^{5} c_k^D$ is the information flow from the stock market conditional on the event. As noted by Acharya and Johnson (2007), the inclusion of the conditional and unconditional lag effects of stock returns ensures that any apparent IV spread lag effects are not artifacts of unmodeled dynamics and helps to capture all other variables associated with price movements. The analysis is conducted on the 10 days before and 10 days after an event.

<Insert Table 8 about here>

Table 8 reports the results; models one through five report results for each of the (five) definitions of events presented above. In all five models, the unconditional information flow parameter from the option market, $\sum_{k=1}^{5} b_k$, is found to be small and insignificant, indicating that there is essentially no unconditional flow from the options to stock markets. We note that this result differs from the findings in Table 4 because this parameter measures the *independent* arrival of information to the option market whereas the results in Table 4 may include both the independent arrival of news and the attribution of past information from both the option and stock markets. Additionally, both the unconditional information flow ($\sum_{k=1}^{5} c_k$) and the conditional information flow ($\sum_{k=1}^{5} c_k^D$) from the stock market are found to be significantly negative in all five models, save one. A significantly negative coefficient on $\sum_{k=1}^{5} c_k^D$ suggests that the stock market

incorrectly anticipates the market reaction of the FOMC announcement. This effect may be attributed to greater informed trading in the options market. Indeed, consistent with this intuition, we find the conditional information flow from option markets, $\sum_{k=1}^{5} b_k^D$, to be significantly positive. An untabulated difference in means *t*-test demonstrates that $\sum_{k=1}^{5} c_k$ is not significantly different from $\sum_{k=1}^{5} c_k^D$ at the 5% level in all five specifications. This suggests that there is no difference between the contribution of information from past stock prices during FOMC meetings and during regular trading days.

For the full sample reported in Model 1, the coefficient for the variable of interest, the conditional information flow measure, $\sum_{k=1}^{5} b_k^D$, is highly significant and represents 6.5% transmission of information in options markets innovations to future stock returns. By comparison, the unconditional information flow parameter is not significantly different from zero. This suggests that the information flow from the option market to the stock market is particularly relevant during FOMC meetings.

A comparison of results for regularly scheduled meetings in Model 2 and conference calls in Model 3 reveals a difference in the transmission of options markets innovations to future stock returns. For regularly scheduled meetings in Model 2, the coefficient of the conditional information flow measure, $\sum_{k=1}^{5} b_k^D$, represents about 3.4% transmission of information in options markets innovation to future stock returns. For unscheduled conference calls in Model 3, $\sum_{k=1}^{5} b_k^D$ represents about 7.4% transmission of information to equity markets. A Chow test confirms that the difference between the conditional information flow for scheduled FOMC meetings and unscheduled conference calls is significant at the 5% level. This result confirms that information flow from the options markets is greater around unexpected events and provides additional evidence that return predictability is greater for unexpected meetings (conference calls) than that for regular FOMC meetings.

Models 4 and 5 show a similar pattern for surprise and non-surprise events (using our second definition of surprise meetings). The conditional information flow parameter for non-surprise events, reported in Model 4, is insignificant. However, for surprise events (reported in Model 5), the coefficient of the conditional information flow measure, $\sum_{k=1}^{5} b_k$, represents a 13.2% transmission of information in options markets innovations to future stock returns. The magnitude of information flow during surprise events is significantly greater than that during non-surprise events; a Chow test reports that the difference between coefficients is significant at the 0.1% level.

These test results provide firm evidence that information revelation (about FOMC rate announcements) in the options market precedes information revelation in the stock market. This finding thus provides further support for Hypotheses #1 and #2. Further, the results regarding surprise rate changes also provide additional support for the finding that informed trading in the options market tends to cluster around events that are informationally asymmetric, a finding consistent with Cao and Ou-Yang (2009). Finally, we find that both the stock and options markets play a considerable role in price discovery. This finding is consistent with a "pooling equilibrium" as suggested by Easley, O'Hara, and Srinivas (1998).

7. Tests of external validity and further analysis

7.1 External validity

One of the primary motivations of this paper is to study the effects of macroeconomic news announcements that are, by their nature, informationally relevant for a broad range of market participants. In this section, we examine whether FOMC announcements increase return predictability in firms in other industries considered to be interest rate sensitive. To the extent that option trades produce information useful in predicting subsequent bank stock returns, it is reasonable to expect similar return predictability for other firms that are sensitive to interest rate

changes. To measure the interest rate sensitivity of individual firms we use the Demsetz and Strahan (1997) multi-factor market model used in Section 6 to construct the interest rate sensitivity control variable. We construct this measure for the nexus of firms from OptionMetrics and CRSP. Firms are then sorted into deciles based on their interest rate sensitivity. We form quintile portfolios based on the IV spread within each interest rate sensitivity decile as of the close of trading the day prior to FOMC meetings. The portfolios are then rebalanced prior to each meeting.

Table 9 reports the one-day portfolio returns sorted by interest rate sensitivity deciles. For each decile we report the quintile portfolio return, alpha, and average volatility spread, as well as hedge portfolio return, alpha, average volatility spread, and average interest rate sensitivity for all the firms in that decile. The table reports a strong positive relationship between returns and interest rate sensitivity, while IV spreads increase almost monotonically as interest rate sensitivity increases, indicating that the degree of interest rate sensitivity is directly associated with the degree of return predictability. Decile 10 reports an alpha of 71.3 bps which is more than double the alpha of 28.0 bps reported for Decile 1; raw returns show a similar pattern of increase. A one-tailed *t*-test (untabulated) that mean risk-adjusted returns for decile 10 are greater than for decile 1 produces a *t*-statistic of 6.81, significant at the 0.01% level.[6]

<Insert Table 9 about here>

For comparative purposes, previously reported results for the banking industry are reported separately at the bottom of the table. Interest rate sensitivity and returns for the banking industry positions it roughly between Deciles 6 and 7, while the volatility spread is lower than that of Decile

[6] As a robustness check, we also segregate firms into industries based on the Fama-French 10 industry definition. This relatively coarse industry definition turns out to be problematic because analysis shows that there is considerable variation in the interest rate sensitivity of firms within each industry, making a comparison of "interest sensitive industries" vs. "non-interest sensitive industries" difficult using the FF 10 industry definition. Despite this shortcoming, the results from this analysis show that more interest rate sensitive industries generally have greater returns and greater IV spreads, although the increases are not monotonic.

1. This result, prima facie, is surprising, however, it is consistent with evidence in Ehrmann and Fratzscher (2004) and Bernanke and Kuttner (2005) that bank stock returns have average sensitivity (among all stocks economy-wide) to monetary policy changes. We note that bank quintile returns are right-skewed compared to non-banks, and the range of returns and volatility spread is relatively tight given its positive skew, suggesting that informed traders perhaps have less disagreement about their forecasts for future bank stock returns.

A detailed examination of the deciles reveals that the most frequently occurring industries (as defined by three-digit SIC code) in Decile 1, the least interest rate sensitive firms with the least return predictability, include the following industries (firms): Utilities (Duke Energy), Energy (Chevron) and Healthcare (Pfizer). Decile 10, the most interest rate sensitive firms with the most return predictability, is dominated by firms in the broader High Tech industry: Citrix Systems, McAfee, Dell Technologies, Nortel Networks and Cree. This result is generally consistent with findings in Bernanke and Kuttner (2005) that firms in the High Tech and Telecommunications industries have the greatest sensitivity to monetary policy changes while firms in the Energy, Utilities and Healthcare industries are the least sensitive. Overall, the results reported in Table 9 extend the main results in this study to show that, in addition to banks, interest rate sensitive firms also experience greater return predictability around FOMC announcement~~s~~ dates.

7.2 Further analysis

As an additional test, we compare the economic magnitudes of risk-adjusted hedge portfolio returns during FOMC meeting days against risk-adjusted hedge portfolio returns during corporate events such as earnings announcements.[7] The results in Appendix B show a mean return of 30.9 bps and a risk-adjusted return of 14.2 bps for the hedge portfolio during bank earnings

[7] For this test we utilize the sample of banks used in the paper's preceding analyses. We exclude any overlap of days in a three-day window around earnings announcement dates and FOMC announcement dates.

announcement dates. A one-tailed *t*-test of the hypothesis that average risk-adjusted returns for FOMC meeting dates are greater than risk-adjusted returns for earnings announcement dates is significant at the 1% level. This result demonstrates that a macro-level event such as a FOMC rate change announcement contains information that is more informationally impactful, on average, than do firm-level announcements.

Evidence in the preceding sections establishes that informed trading in the options market prior to federal funds rate changes predicts future bank stock returns. However, prior studies find that some future stock returns reflect information from informed option traders in the form of both volatility spread and volatility skewness (see, e.g., Xing, Zhang, and Zhao, 2010; Jin, Livnat, and Zhang, 2012; and Gharghori, Maberly, and Nguyen, 2017). To examine this possibility, and the sensitivity of our findings to an alternative measure of informed trading, we calculate bank stock returns for portfolios formed on volatility skew. We compute volatility skew for option contracts with time to expiration from 10 to 60 days as the implied volatility of out-of-money put options minus the implied volatility of at-the-money call options (following the method used by Jin, Livnat, and Zhang, 2012 and Gharghori, Maberly, and Nguyen, 2017).

Appendix C reports daily returns for bank stock portfolios formed based on volatility skew as of the close of trading the day prior to FOMC announcement days. Day one portfolio returns demonstrate that, as predicted, stocks with low volatility skew generally have higher next day raw and risk-adjusted returns than do stocks with high volatility skew. Mean and risk-adjusted returns for the hedge portfolios are generally negative. This initial result is opposite of the effect of volatility spread, demonstrating that skewness does not drive the return predictability observed on FOMC announcement days.

Appendix D reports daily returns for bank stock portfolios on non-meeting days. Results show that stocks with low volatility skew have significantly higher next day raw and risk-adjusted

returns than do stocks with high volatility skew. The mean and risk-adjusted returns for the hedge portfolios all are significantly negative. Untabulated results from *t*-tests show that mean risk-adjusted returns on meeting days are not significantly different than returns on non-meeting days. However, a *t*-test of the difference in raw returns is significant at the 0.1% level.

The result that skewness-based hedge portfolio risk-adjusted returns are not significantly different between meetings and non-meetings days indicates that tail risk is similar, on average, on Federal Reserve meeting dates and non-meeting trading days. Thus, we can conclude that volatility skewness does not drive the return predictability observed around FOMC announcement dates.

8. Conclusion

The purpose of this study is to examine the informational role of bank equity options trading around Federal Reserve FOMC meetings. We examine this macro-level event to determine if options trades contain significant information about future stock returns when the event provides market-wide information, relevant to all firms, not just idiosyncratic information relevant only to the underlying stock. Our evidence supports the hypothesis that information contained in option trades prior to federal funds rate change announcements measured as implied volatility spread, predicts bank stock returns to a greater degree than do IV spreads prior to non-meeting days.

Importantly, our evidence also supports the hypothesis that return predictability is driven primarily by surprise changes in interest rates. These results confirm findings in past studies that options trading activity often clusters around events with high degrees of information asymmetry. In addition, we show that IV spread impounds information about FOMC meetings before that information is reflected in stock prices and that contribution of information from IV spread to the

stock market is significantly greater during surprise events, suggesting that the option market is an important source of informed trading.

We highlight as an intriguing topic for future research the link between our findings and a recent strand of literature that examines the aggregate variance risk premium.[8] Bollerslev, Tauchen, and Zhou (2009) and Bekaert and Hoerova (2014) show that the aggregate variance risk premium (derived from the VIX) predicts aggregate stock returns. As part of their work on the dynamic relationship between the aggregate variance risk premium, uncertainty and monetary policy, Bekaert, Hoerova, and Duca (2013) demonstrate that the time series for expected stock market volatility (a proxy for uncertainty) and the variance risk premium (a proxy for risk aversion) spike around periods of severe market distress. We note that the frequency of our measures of information asymmetry, surprise FOMC meetings and conference calls, also increase during times of crisis and uncertainty in monetary policy. Because extant literature finds a positive relationship between uncertainty and information asymmetry (Varian, 1985; Nagar, Schoenfeld, and Wellman, 2017 and 2018), it may be that informed traders possessing superior, private information about the sensitivities of individual bank stocks to variance risk, interest rate risk, the changing likelihood (or path) of future monetary policy, or all three, trade in the options market ahead of monetary policy decisions. This interpretation explains the observed stock return predictability and provides further support for the finding that the variance risk premium exhibits considerable cross-sectional variation (Carr and Wu, 2009). We hope our findings and insight provide a useful springboard for further research.

[8] We thank the editor for highlighting this possibility.

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Appendix A: Variable definitions

This table defines the variables used in this study.

Variable	Definition	Source
FF rate change	Change in the FOMC's target federal funds rate	Board of Governors of the Federal Reserve System
Unexpected rate change	Unexpected, or surprise, element of changes in the federal funds target rate	Extracted from daily changes in the implied target rate of the current-month federal funds futures contract using the technique in Kuttner (2001) and in Section 3
Volatility spread	Weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days	OptionMetrics; see Xing, Zhang, and Zhao (2010) and Jin, Livnat, and Zhang (2012)
Volatility skew	The implied volatility of out-of-money put option minus the implied volatility of at-the-money call option	OptionMetrics; see Jin, Livnat, and Zhang (2012) and Gharghori, Maberly, and Nguyen (2017); see Section 7.2
Interest rate sensitivity	Degree of equity sensitivity to interest rate changes	Estimated using a multi-index market model in Section 3
Monetary cycle	Binary variable equal to 1 for each firm/day observation during a period of rising federal funds rates	See Adrian, Estrella, and Shin (2010)
FOMC meeting dummy	Binary variable equal to 1 if firm/day observation is a FOMC announcement day	
Conference call meeting dummy	Binary variable equal to 1 if firm/day observation is a FOMC announcement day resulting from a conference call meeting	
Surprise rate change dummy	Binary variable equal to 1 if firm/day observation is a FOMC announcement day that results in an unexpected change in the target rate that is greater than the absolute value of 12.5 bps	

Appendix B: Earnings announcements portfolio returns

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads, for bank earnings announcement dates. The volatility spread is observed as of the close of the trading the day prior to bank quarterly earnings announcements. The sample excludes any overlap of days in a three-day window around earnings announcement dates and FOMC announcement dates. Performances for quintiles are the returns for long positions in each quintile. Performances for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. *t*-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread.

	Volatility Spread Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Return	-24.8	-7.3	-1.9	20.1	6.1	30.9	14.2
Alpha	-3.5	-9.6	-0.1	14.2	10.7	(1.49)	(0.81)
	(0.27)	(0.85)	(0.01)	(1.27)	(0.90)		
R^2	0.001	0.000	0.025	0.001	0.025	0.000	

Appendix C: Daily returns on volatility skewness portfolios on FOMC announcements

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility skewness. Volatility skewness is measured as the implied volatility of out-of-money put option minus the implied volatility of at-the-money call option (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. Volatility skewness is observed as of the close of day immediately prior to federal funds announcement days (t-1). Returns are from the close on day t-1 (t) to the close on day t (t+1), reported under *Day one* (*Day two*). Performances for quintiles are returns for long positions in each quintile. Performances for hedge portfolios are the returns for a portfolio which is long high volatility skewness stocks and short low volatility skewness stocks. Panel A reports portfolio returns for the full sample period 1996 to 2008. Panel B reports portfolio returns for period 1996 to 2002. Panel C reports portfolio returns for period 2003 to 2008. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. t-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Skewness Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Full sample							
Day one							
Return	78.4 ***	54.7 ***	33.3 ***	63.7 ***	49.0 ***	-29.5	-19.5 *
Alpha	23.5 **	13.6 **	3.1	9.0	4.0	(0.68)	(2.16)
	(3.26)	(2.79)	(0.83)	(1.52)	(0.75)		
R^2	0.001	0.000	0.014	0.008	0.000	0.001	
Day two							
Return	10.0	28.8 ***	5.0	18.7 *	16.5 *	6.5	-11.1
Alpha	15.0 *	7.9	2.0	8.6	3.9	(0.96)	(1.35)
	(2.42)	(1.71)	(0.55)	(0.46)	(0.71)		
R^2	0.002	0.011	0.003	0.007	0.003	0.002	
Panel B: 1996 to 2002							
Day one							
Return	72.2 ***	25.5 ***	72.2 ***	46.8 ***	41.1 **	-31.1	-30.3 **
Alpha	23.7 **	7.9	8.1	7.2	-6.6	(1.34)	(2.67)
	(2.75)	(1.28)	(1.10)	(0.88)	(0.89)		
R^2	0.005	0.004	0.002	0.000	0.007	0.001	
Day two							
Return	-5.0	28.6 ***	-8.1	18.8 *	11.4	16.4	-4.3
Alpha	0.0	6.4	-12.0	9.5	-4.3	(1.34)	(0.38)
	(0.00)	(1.03)	(1.75)	(1.25)	(0.57)		
R^2	0.001	0.000	0.013	0.002	0.002	0.001	
Panel C: 2003 to 2008							
Day one							
Return	85.8 ***	85.0 ***	5.0	83.7 ***	56.6 ***	-29.2	-5.1
Alpha	13.7	18.2 *	-2.6	8.1	8.6	(0.08)	(0.35)
	(1.14)	(2.34)	(0.57)	(0.94)	(1.09)		
R^2	0.004	0.003	0.017	0.019	0.001	0.001	
Day two							
Return	27.6	29.1 **	14.5	18.5	21.4	-6.2	-23.1
Alpha	34.2 ***	5.4	13.1 **	6.8	11.1	(0.23)	(1.94)
	(3.84)	(0.78)	(3.08)	(0.86)	(1.40)		
R^2	0.009	0.017	0.002	0.013	0.003	0.001	

Appendix D: Daily returns on volatility skewness portfolios on non-meeting days

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility skewness. Volatility skewness is measured as the implied volatility of out-of-money put option minus the implied volatility of at-the-money call option (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. Volatility skewness is observed as of the close of day immediately prior to the next trading day that is not a federal funds announcement day (*t*-1). Returns are from the close on day *t*-1 to the close on day *t*, reported under *Day one* (*Day two*). Performances for quintiles are returns for long positions in each quintile. Performances for hedge portfolios are the returns for a portfolio which is long high volatility skewness stocks and short low volatility skewness stocks. Panel A reports portfolio returns for the full sample period 1996 to 2008. Panel B reports portfolio returns for period 1996 to 2002. Panel C reports portfolio returns for period 2003 to 2008. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. *t*-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Skewness Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Full sample							
Return	14.4 ***	1.9	3.3 ***	1.4	-8.0 ***	-22.4 ***	-21.4 ***
Alpha	13.2 ***	-0.7	0.5	1.1	-8.2 ***	(12.37)	(16.01)
	(12.84)	(1.04)	(0.77)	(1.24)	(9.62)		
R^2	0.004	0.004	0.002	0.001	0.003	0.005	
Panel B: 1996 to 2002							
Return	21.9 ***	5.1 ***	8.0 ***	5.5 ***	-6.2 ***	-28.1 ***	-27.4 ***
Alpha	10.3 ***	-8.9 ***	-2.8 **	-6.6 ***	-17.1 ***	(11.62)	(14.58)
	(7.45)	(8.78)	(2.65)	(5.44)	(13.44)		
R^2	0.002	0.000	0.002	0.000	0.001	0.005	
Panel C: 2003 to 2008							
Return	2.3	-5.8 ***	-1.2	-5.6 **	-10.4 ***	-12.7 ***	-12.9 ***
Alpha	7.1 ***	-1.7	-2.7 ***	1.5	-5.8 ***	(5.44)	(6.42)
	(4.37)	(1.85)	(3.47)	(1.10)	(4.93)		
R^2	0.006	0.008	0.006	0.004	0.005	0.005	

Figure 1: Framework of empirical analysis

This figure presents the design of our empirical analysis to examine the relation between informed options trading (during federal funds rate change announcement) and stock returns. Option market investors' information acquisition and expectation of federal funds rate change are reflected by interest rate-induced option trade, which is measured by the implied volatility spread ($VS_{i,t\text{-}1}$) and defined in Equation (1) in Section 2. For the banking industry setting, we examine whether implied volatility spread $VS_{i,t\text{-}1}$ (in (A) option market below) can predict future stock returns $Return_{i,t+n}$ (in (B) stock market below) where n = 0, 1 and i denotes firm i.

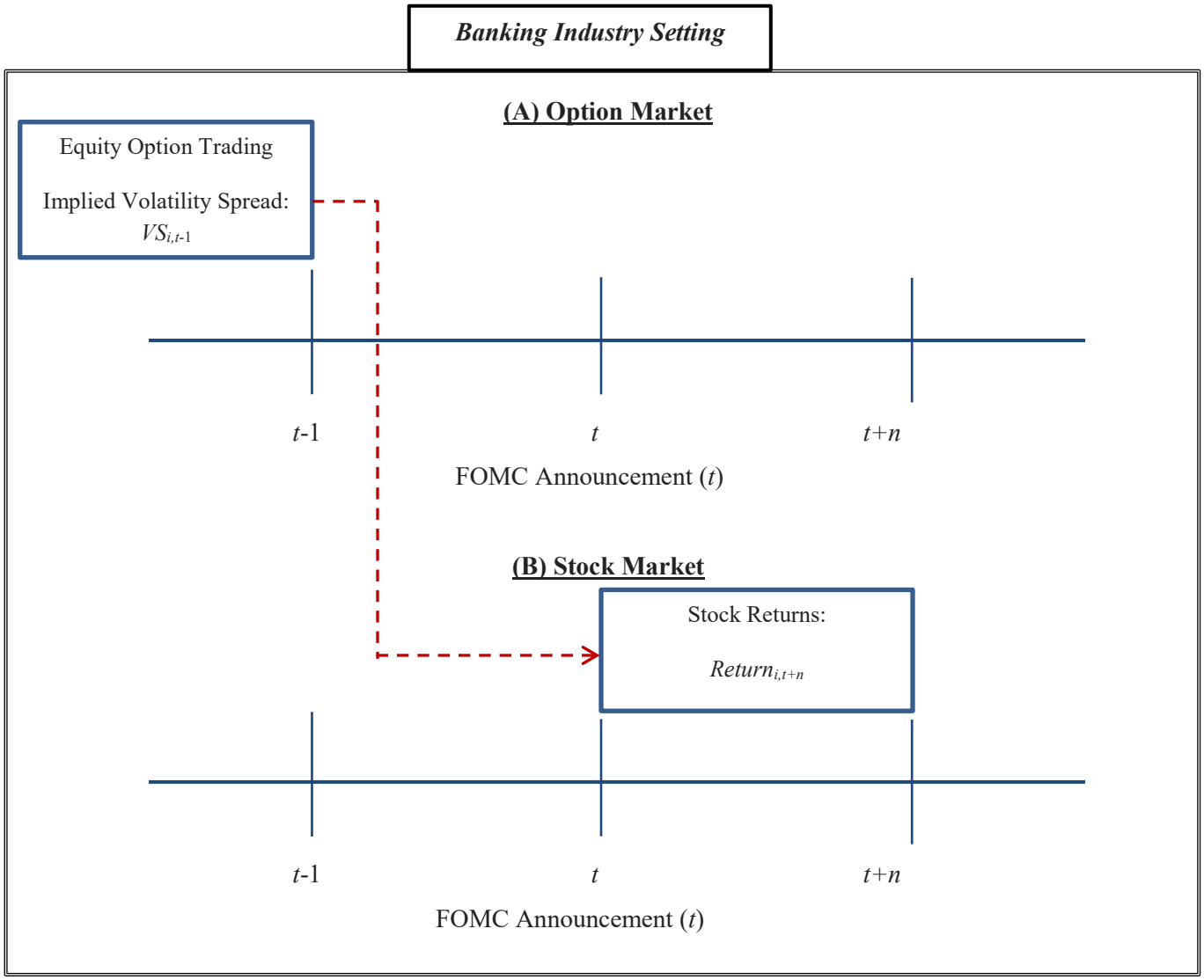

Figure 2: Time series of federal funds rate changes and bank stock returns

This figure presents a time-series plot of raw federal funds rate changes compared to the median daily bank stock return on announcement day for the period from 1996 to 2008.

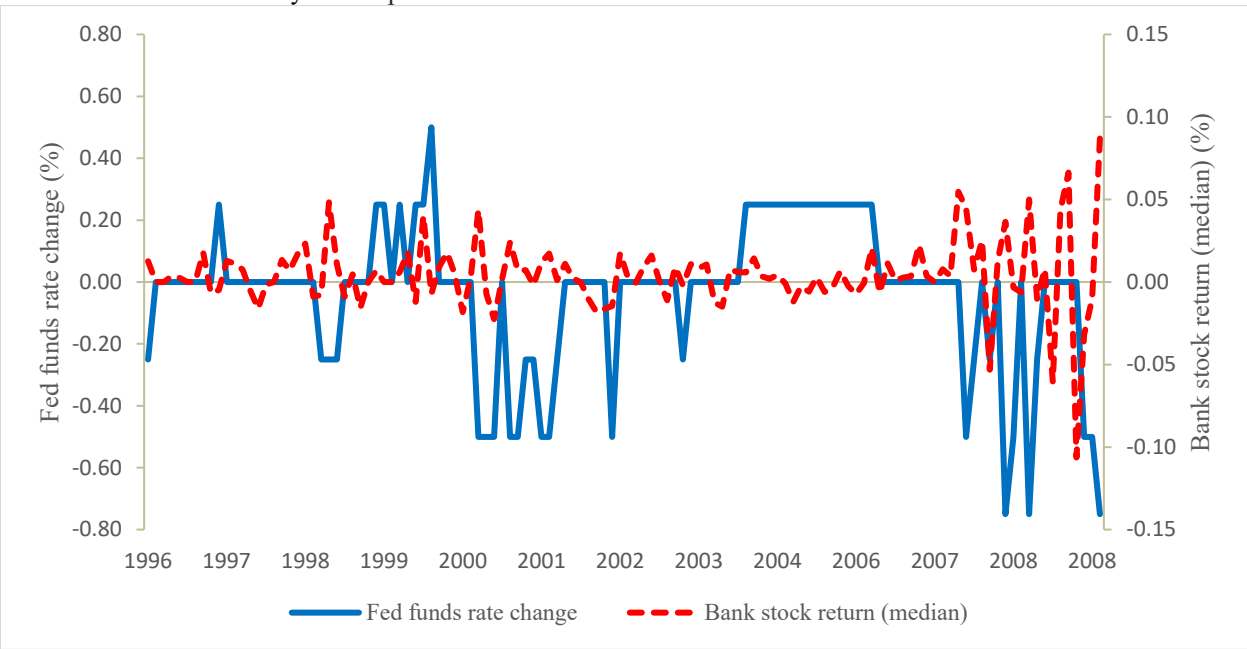

Figure 3: Distribution of federal funds rate changes and bank stock returns

This figure presents federal funds rate changes compared to the median daily bank stock return on announcement day over the period 1996 to 2008.

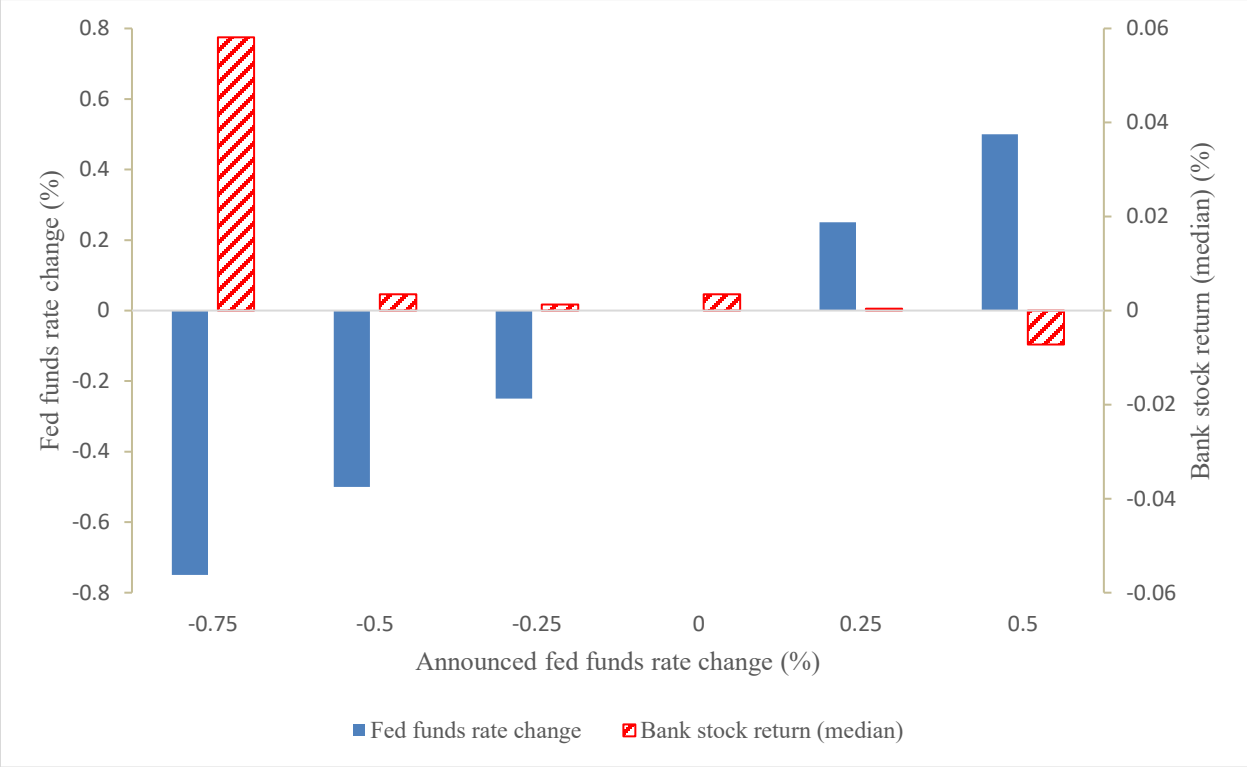

Table 1: Summary statistics of FOMC meeting and non-meeting days

This table presents descriptive statistics for FOMC meeting and non-meeting days. FOMC meeting day is defined as the day on which the FOMC makes an announcement about a considered change to the federal funds target rate. # of events is the number of FOMC meetings. Scheduled is the number (count) of regularly scheduled FOMC meetings. Conference call is the number (count) of unscheduled meetings. Mean unexp. change in Fed Funds rate is the mean of the unexpected element of changes in the federal funds target rate, constructed following Kuttner (2001). # of surprise rate changes in the number (count) of meeting days in which the absolute value of the unexpected change in the target rate is greater than or less than 12.5 bps. Panel D reports on meetings in which there was no change in the federal funds target rate. Panel E reports on meetings in which there was an increase in the federal funds target rate. Panel F reports on meetings in which there was a decrease in the federal funds target rate. Panel G reports on non-meeting days, defined as days outside a three-day window around each federal funds announcement day.

	Scheduled	Conference call
Panel A: All events		
# of events	103	18
Mean unexp. change in Fed Funds rate	-0.01	-0.12
# of surprise rate changes	9	5
Panel B: 1996 to 2002		
# of events	55	5
Mean unexp. change in Fed Funds rate	0.02	-0.22
# of surprise rate changes	3	3
Panel C: 2003 to 2008		
# of events	48	13
Mean unexp. change in Fed Funds rate	-0.05	-0.08
# of surprise rate changes	6	2
Panel D: No rate change		
# of events	58	13
Mean unexp. change in Fed Funds rate	-0.01	-0.01
Panel E: Positive rate change		
# of events	24	0
Mean unexp. change in Fed Funds rate	0.01	N/A
Panel F: Negative rate change		
# of events	21	5
Mean unexp. change in Fed Funds rate	-0.05	-0.39
Panel G: Non-meeting days		
# of events	N/A	N/A
# of days	2,909	2,909
Mean unexp. change in Fed Funds rate	N/A	N/A

Table 2: Summary statistics of implied volatility spreads

This table presents summary statistics for the volatility spreads of bank stocks. Panel A reports FOMC meeting days and Panel B reports non-meeting days. Non-meeting days include all days outside of a three-day window of an FOMC meeting. Volatility spread is measured as the open interest-weighted average difference in implied volatilities between calls and puts (with the same strike price and maturity) across all option pairs with time to expiration of 10 to 60 days for an underlying stock on a given day. The volatility spread is observed as of the close of day immediately prior to federal funds announcement days (*t*-1). Volatility spreads are expressed in percentages.

Variable	Mean	Median	Std. Dev.	N
Panel A: FOMC meeting days				
All observations	-0.93	-0.37	4.06	7,745
Quintiles:				
(1)	-5.95	-4.65	4.31	1,503
(2)	-2.13	-1.63	2.15	1,568
(3)	-0.65	-0.36	1.31	1,573
(4)	0.48	0.29	1.13	1,582
(5)	3.53	2.53	3.05	1,519
Panel B: Non-meeting days				
All observations	-0.83	-0.35	3.54	181,712
Quintiles:				
(1)	-5.35	-4.26	3.70	35,185
(2)	-1.90	-1.53	1.59	36,841
(3)	-0.57	-0.36	0.85	37,178
(4)	0.40	0.23	0.77	36,920
(5)	3.22	2.41	2.63	35,588

Table 3: Daily returns on volatility spread portfolios on FOMC meeting days

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads. Volatility spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. The volatility spread is observed as of the close of day immediately prior to federal funds announcement days (t-1). Returns are from the close on day t-1 (t) to the close on day t (t+1), reported under *Day one* (*Day two*). Performances for quintiles are the returns for long positions in each quintile. Performances for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. Panel A reports portfolio returns for the full sample period 1996 to 2008. Panel B reports portfolio returns for period 1996 to 2002. Panel C reports portfolio returns for period 2003 to 2008. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. t-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Spread Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Full sample							
Day one							
Return	38.9 ***	47.2 ***	52.9 ***	56.7 ***	68.7 ***	29.8 **	38.9 ***
Alpha	-9.9	3.1	11.8 *	14.6 **	29.0 ***	(2.85)	(5.02)
	(1.82)	(0.62)	(2.44)	(2.90)	(5.24)		
R^2	0.007	0.027	0.083	0.049	0.005	0.008	
Day two							
Return	24.7 ***	8.5	21.6 **	5.8	20.6 **	-4.1	0.3
Alpha	12.8 *	-3.0	16.4 ***	-4.3	13.1 **	(0.38)	(0.04)
	(2.32)	(0.67)	(3.42)	(0.88)	(2.65)		
R^2	0.007	0.028	0.061	0.078	0.002	0.002	
Panel B: 1996 to 2002							
Day one							
Return	40.1 ***	40.3 ***	46.4 ***	58.8 ***	62.0 ***	21.9	31.1 **
Alpha	-6.3	-5.4	1.3	24.0 **	24.8 **	(1.87)	(2.89)
	(0.82)	(0.77)	(0.18)	(3.30)	(3.26)		
R^2	0.002	0.029	0.006	0.003	0.003	0.002	
Day two							
Return	16.2	13.2	13.2	6.5	3.1	-13.1	-9.0
Alpha	4.0	-1.1	8.8	-2.4	-5.0	(1.10)	(0.86)
	(0.52)	(0.16)	(1.27)	(0.33)	(0.70)		
R^2	0.000	0.001	0.001	0.001	0.001	0.000	
Panel C: 2003 to 2008							
Day one							
Return	37.8 **	54.0 ***	59.2 ***	54.6 ***	75.4 ***	37.6 *	45.6 ***
Alpha	-17.0 *	3.4	17.3 *	6.0	28.6 ***	(2.18)	(4.02)
	(2.16)	(0.47)	(2.53)	(0.84)	(3.50)		
R^2	0.020	0.069	0.153	0.093	0.007	0.015	
Day two							
Return	33.0 **	3.8	29.8 *	5.1	37.7 **	4.6	8.5
Alpha	21.3 **	-3.8	24.0 ***	-4.3	29.8 ***	(0.30)	(0.82)
	(2.70)	(0.62)	(3.64)	(0.64)	(4.41)		
R^2	0.015	0.050	0.173	0.143	0.005	0.004	

Table 4: Daily returns on volatility spread portfolios on non-meeting days

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads. Volatility spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. The volatility spread is observed as of the close of day immediately prior to a non-meeting day (all days outside of a three-day window of an FOMC meeting). Returns are measured in the following trading day. Performances for quintiles are the returns for long positions in each quintile. Performances for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. Panel A reports portfolio returns for the full sample period 1996 to 2008. Panel B reports portfolio returns for period 1996 to 2002. Panel C reports portfolio returns for period 2003 to 2008. Panel D reports the difference in returns between FOMC meeting days and non-meeting days for the full sample period. Statistical significance for difference testing is based on one-tailed p-values of tests of the hypothesis that returns on FOMC meeting days are greater than that of non-meeting days. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. *t*-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Spread Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Full sample							
Return	-12.8 ***	-3.5 ***	1.3	6.5 ***	16.0 ***	28.8 ***	28.6 ***
Alpha	-14.0 ***	-4.7 ***	0.5	5.3 ***	14.6 ***	(19.17)	(24.70)
	(16.80)	(6.28)	(0.62)	(6.83)	(18.14)		
R^2	0.004	0.004	0.004	0.004	0.002	0.007	
Panel B: 1996 to 2002							
Return	-11.4 ***	0.0	4.6 ***	14.1 ***	23.6 ***	34.9 ***	35.0 ***
Alpha	-23.4 ***	-12.0 ***	-6.6 ***	1.7	11.6 ***	(17.01)	(20.19)
	(18.89)	(10.62)	(5.93)	(1.44)	(9.54)		
R^2	0.003	0.000	0.000	0.000	0.001	0.008	
Panel C: 2003 to 2008							
Return	-14.7 ***	-8.0 ***	-3.0 *	-3.0	6.5 ***	21.2 ***	21.3 ***
Alpha	-11.8 ***	-4.8 ***	-0.4	0.5	9.5 ***	(9.61)	(13.52)
	(10.39)	(4.63)	(0.41)	(0.52)	(8.69)		
R^2	0.008	0.013	0.014	0.011	0.002	0.007	
Panel D: Difference in returns							
Difference in full sample returns						1.00 ***	10.28 **
						(9.87)	(2.62)

Table 5: Daily returns on volatility spread portfolios on rate announcement dates, by meeting type

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads, and reported by meeting type. Volatility spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. The volatility spread is observed as of the close of day immediately prior to federal funds announcement days (t-1). Returns are from the close on day t-1 (t) to the close on day t (t+1), reported under *Day one* (*Day two*). Performances for quintiles are returns for long positions in each quintile. Performance for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. Panel A reports portfolio returns for conference call meetings. Panel B reports portfolio returns for regular meetings. Panel C reports the difference in returns between conference call days and regularly scheduled meeting days for the full sample period. Statistical significance for difference testing is based on one-tailed p-values of tests of the hypothesis that returns on conference call days are greater than that of regularly scheduled meeting days. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. t-statistics are reported in parentheses. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Spread Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Conference call							
Day one							
Return	12.5	28.2	28.9	53.8 *	55.2	42.8	62.6 *
Alpha	5.0	23.3	23.9	20.9	67.6 **	(1.06)	(2.04)
	(0.24)	(1.07)	(1.26)	(1.01)	(3.01)		
R^2	0.157	0.157	0.143	0.002	0.035	0.018	
Day two							
Return	126.1 ***	85.7 **	155.0 ***	90.0 **	132.4 ***	6.3	9.6
Alpha	11.0	-36.1 *	53.4 *	-23.7	20.6	(0.21)	(0.34)
	(0.51)	(1.99)	(2.54)	(1.10)	(1.11)		
R^2	0.001	0.016	0.083	0.145	0.001	0.000	
Panel B: Regular meeting							
Day one							
Return	43.7 ***	50.7 ***	57.2 ***	57.2 ***	71.2 ***	27.5 **	34.6 ***
Alpha	-11.1 *	4.0	11.4 *	8.7	23.5 ***	(2.75)	(4.44)
	(2.01)	(0.82)	(2.32)	(1.75)	(4.28)		
R^2	0.004	0.000	0.055	0.095	0.032	0.004	
Day two							
Return	6.5	-5.7	-2.1	-8.7	0.2	-6.2	-0.9
Alpha	8.4	2.1	12.0 *	0.1	7.5	(0.68)	(0.11)
	(1.49)	(0.45)	(2.51)	(0.03)	(1.46)		
R^2	0.008	0.025	0.040	0.062	0.006	0.004	
Panel C: Difference in returns							
Difference in returns						15.25	28.01 *
						(1.11)	(1.75)

Table 6: Daily returns on volatility spread portfolios on rate announcement dates, surprise vs. non-surprise

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads, and reported by surprise vs. non-surprise events. Volatility spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. The volatility spread is observed as of the close of day immediately prior to federal funds announcement days (t-1). Returns are from the close on day t-1 (t) to the close on day t (t+1), reported under *Day one* (*Day two*). Performances for quintiles are returns for long positions in each quintile. Performance for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. Panel A reports portfolio returns for surprise events. Panel B reports portfolio returns for non-surprise events. A surprise (non-surprise) event is an FOMC meeting in which the absolute value of unexpected changes in the federal funds rate is greater (less) than 12.5 bps. Panel C reports the difference in returns between surprise events and non-surprise events for the full sample period. Statistical significance for difference testing is based on one-tailed p-values of tests of the hypothesis that returns during surprise events are greater than that of non-surprise events. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. t-statistics are reported in parentheses. R^2 is produced by regressing that quintile's daily return on that quintile's prior day volatility spread. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

	Volatility Spread Quintiles					Hedge Portfolio	
	(1)	(2)	(3)	(4)	(5)	Return	Alpha
Panel A: Surprise rate change							
Day one							
Return	121.6 ***	166.0 ***	142.2 ***	145.3 ***	174.8 ***	53.2	112.1 **
Alpha	-62.1 *	26.0	1.2	4.7	50.0	(1.31)	(2.86)
	(2.48)	(0.87)	(0.05)	(0.19)	(1.65)		
R^2	0.070	0.013	0.034	0.014	0.018	0.014	
Day two							
Return	52.4	-25.7	-14.9	-2.0	6.3	-46.1	-30.8
Alpha	70.0	-52.3	50.8	-28.4	39.2	(0.97)	(0.51)
	(1.76)	(1.24)	(1.24)	(0.74)	(0.85)		
R^2	0.001	0.011	0.046	0.233	0.075	0.008	
Panel B: Non-surprise rate change							
Day one							
Return	28.0 ***	31.6 ***	41.3 ***	44.9 ***	54.6 ***	26.6 *	33.5 ***
Alpha	-7.0	0.7	13.6 **	15.7 **	26.5 ***	(2.53)	(4.39)
	(1.29)	(0.14)	(2.88)	(3.13)	(4.96)		
R^2	0.005	0.065	0.142	0.074	0.011	0.008	
Day two							
Return	18.9 **	11.5	25.9 ***	6.2	21.8 **	2.9	4.6
Alpha	8.8	1.4	17.4 ***	-2.8	13.4 **	(0.31)	(0.61)
	(1.54)	(0.31)	(3.52)	(0.56)	(2.72)		
R^2	0.013	0.044	0.086	0.030	0.001	0.001	
Panel C: Difference in returns							
Difference in returns						26.59 ***	78.55 ***
						(5.20)	(3.90)

Table 7: Regression of daily bank stock returns on explanatory variables

This table presents the results from panel regression analysis of daily bank stock returns on explanatory variables for the 1996 to 2008 sample period. To control for unobserved firm heterogeneity, panel regressions are estimated with firm fixed-effects. Following the approach of Petersen (2009), regressions also incorporate time fixed-effects (year dummies), while standard errors are corrected for clustering at the bank level. Models 1, 2 and 3 examine the effects on FOMC meeting days, Model 4 on non-meeting days and Models 5, 6 and 7 on meeting and non-meeting days. The volatility spread is observed as of the close of day *t*-1. Returns and rate changes are from the close on day *t*-1 to the close on day *t*. FF rate change is the change in the FOMC's target federal funds rate. Unexpected rate change is the unexpected element of changes in the federal funds target rate, constructed following Kuttner (2001). Volatility spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. Interest rate sensitivity is the sensitivity of banks' common stock to changes in interest rate. Monetary cycle is a binary variable equal to 1 for each firm/day observation during a period of rising federal funds rates. FOMC meeting dummy is a binary variable equal to 1 if a firm/day observation is a FOMC announcement day. Conference call meeting dummy is a binary variable equal to 1 if firm/day observation is a FOMC announcement day resulting from a conference call meeting. Surprise rate change dummy is a binary variable equal to 1 if firm/day observation is a FOMC announcement day that results in an unexpected change in the target rate that is greater than the absolute value of 12.5 bps. *t*-statistics reported in parentheses are corrected for clustering at the bank level. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

Dependent Variable = Return							
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FF rate change	-2.69 ***	-2.21 ***	-2.71 ***		-1.76 ***	-2.00 ***	-1.89 ***
	(9.87)	(7.83)	(8.92)		(13.58)	(14.34)	(13.32)
Unexpected rate change	-0.83 *	-1.59 ***	-0.72 *	0.41 ***	0.19 *	0.15	0.14
	(2.35)	(4.22)	(2.00)	(4.37)	(2.04)	(1.57)	(1.53)
Volatility spread	0.10 ***	0.09 ***	0.10 ***	0.04 ***	0.04 ***	0.04 ***	0.04 ***
	(8.18)	(6.81)	(7.60)	(20.14)	(20.41)	(17.81)	(20.53)
Monetary cycle	1.04 ***	0.92 ***	1.04 ***	-0.01	0.01	0.03 *	0.01
	(10.27)	(8.94)	(9.88)	(0.83)	(0.40)	(2.31)	(0.39)
Interest rate sensitivity	-0.018 ***	-0.017 ***	-0.018 ***	-0.001	-0.002 ***	-0.003 ***	-0.002 ***
	(4.91)	(4.74)	(4.96)	(1.42)	(4.07)	(4.31)	(4.11)
FOMC meeting dummy					0.45 ***		
					(17.85)		
Conference call meeting dummy		-0.73 ***				0.14	
		(5.76)				(1.55)	
Surprise rate change dummy			-0.02				0.29 ***
			(0.21)				(3.94)
FOMC meet x Vol spread					0.04 ***		
					(3.91)		
Conf call meet x Vol spread		0.04				0.07 *	
		(1.12)	-0.03			(2.48)	
Surprise change x Vol spread			(0.85)				0.08 ***
							(3.46)
Constant	-0.11	0.27	-0.10	-0.28 ***	-0.18 ***	-0.19 ***	-0.17 ***
	(0.88)	(1.97)	(0.84)	(10.52)	(7.79)	(8.20)	(7.07)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.06	0.07	0.06	0.01	0.01	0.01	0.01
Observations	7,745	7,745	7,745	181,712	197,278	190,820	197,278

Table 8: Conditional information flow

We estimate a panel specification regressing the stock returns on the past five lags of stock returns, the past five lags of option market innovations, and the products of a FOMC meeting dummy variable with the former two variables:

$$(\text{return})_t = a + \sum_{k=1}^{5}[b_k + b_k^D(\text{D})_t](\text{U})_{t-k} + \sum_{k=1}^{5}[c_k + c_k^D(\text{D})_t](\text{return})_{t-k} + \varepsilon_t$$

where D is equal to unity in the five days prior to a FOMC meeting event, U is the option market innovation from Equation (6), $\sum_{k=1}^{5} b_k$ is the unconditional information flow from the options markets, and $\sum_{k=1}^{5} b_k^D$ is the conditional information flow from the option market on the FOMC meeting event. Reported in parentheses are *t*-statistics. The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

Variables	(1) All FOMC	(2) Scheduled	(3) Conference call	(4) Non-surprise	(5) Surprise
a	0.002 ***	0.002	0.001 ***	0.001 *	0.001 ***
	(6.42)	(1.24)	(8.53)	(2.21)	(4.53)
$\sum b_k$	-0.002	0.001	-0.002	0.001	-0.001
	(1.71)	(0.51)	(1.75)	(0.92)	(0.22)
$\sum b_k^D$	0.065 ***	0.034 *	0.074 ***	0.004	0.132 ***
	(9.42)	(1.99)	(12.81)	(0.26)	(14.29)
$\sum c_k$	-0.031 ***	-0.062 ***	-0.021 ***	-0.038 ***	-0.03 ***
	(12.14)	(10.35)	(5.63)	(7.32)	(8.22)
$\sum c_k^D$	-0.062 ***	-0.089 ***	-0.029 ***	-0.082 ***	-0.014
	(3.70)	(4.54)	(3.84)	(5.93)	(1.85)
F-statistic	214.9	153.5	205.5	178.4	195.0
Adj. R-squared	0.01	0.01	0.02	0.01	0.02

Table 9: Daily returns on volatility spread portfolios on FOMC meeting days for all firms, sorted by interest rate sensitivity

This table presents the performance of quintile and hedge portfolios, formed on the level of volatility spreads for the nexus of firms from OptionMetrics and CRSP, sorted by interest rate sensitivity decile. The volatility spread is observed as of the close of day immediately prior to federal funds announcement days (*t*-1). Returns are from the close on day *t*-1 (*t*) to the close on day *t* (*t*+1), reported under *Day one* (*Day two*). Performances for quintiles are the returns for long positions in each quintile. Performance for hedge portfolios are the returns for a portfolio which is long high volatility spread stocks and short low volatility spread stocks. Return is mean unconditional return, expressed in basis points and not annualized. Alpha is risk-adjusted return defined as the constant from a five factor model that included the three Fama-French (1993) factors, a Carhart (1997) momentum factor, and an industry-specific factor. Alpha is expressed in basis points and is not annualized. IV Spread is the weighted difference in implied volatilities between call and put options (with the same strike price and maturity) across all option pairs with time to expirations of 10 to 60 days. Quintile and decile IV spread report the mean volatility spread. Interest rate coefficient reports the mean interest rate sensitivity for all the firms in that decile. Banking reports on our core sample, as reported in Day one for the full sample in Table 3. *t*-statistics are reported in parentheses The symbols *, **, and *** denote statistical significance at the 0.05, 0.01 and 0.001 levels, respectively.

		Volatility Spread Quintiles					Hedge Portfolio			Int. Rate
		(1)	(2)	(3)	(4)	(5)	Return	Alpha	IV Spread	Coeff.
Decile 1	Return	16.6	26.2	25.6	37.6	43.6	27.1	28.0	14.9	0.004
	Alpha	-18.3	-7.0	-1.8	5.8	9.7				
	IV Spread	-8.9	-2.7	-0.7	0.7	5.9				
Decile 2	Return	24.4	35.0	29.5	42.4	50.2	25.8	26.5	14.8	0.014
	Alpha	-11.3	2.3	1.0	9.6	15.2				
	IV Spread	-8.8	-2.7	-0.7	0.7	6.0				
Decile 3	Return	13.9	26.3	34.7	38.3	49.3	35.5	37.1	15.6	0.023
	Alpha	-24.0	-4.4	1.8	7.8	13.1				
	IV Spread	-9.3	-2.8	-0.7	0.8	6.3				
Decile 4	Return	24.0	22.7	28.2	37.7	49.6	25.6	26.7	16.1	0.034
	Alpha	-13.8	-13.5	-4.6	4.3	12.9				
	IV Spread	-9.5	-2.8	-0.7	0.8	6.6				
Decile 5	Return	20.5	30.7	32.4	38.1	44.0	23.5	20.5	16.4	0.047
	Alpha	-17.9	-4.5	0.0	3.1	2.6				
	IV Spread	-9.7	-2.9	-0.7	0.9	6.8				
Decile 6	Return	26.3	22.1	37.5	40.3	57.2	30.9	35.5	17.2	0.061
	Alpha	-18.5	-16.3	2.4	3.6	17.0				
	IV Spread	-9.9	-2.9	-0.7	1.0	7.3				
Decile 7	Return	13.6	25.9	32.4	50.1	67.9	54.3	51.5	18.0	0.079
	Alpha	-28.3	-16.6	-2.6	11.8	23.2				
	IV Spread	-10.4	-3.0	-0.8	1.0	7.7				
Decile 8	Return	13.2	21.0	40.6	44.8	58.7	45.5	45.1	19.6	0.103
	Alpha	-34.6	-19.3	1.8	0.7	10.5				
	IV Spread	-11.4	-3.3	-0.8	1.2	8.3				
Decile 9	Return	19.1	34.8	44.7	51.0	74.9	55.8	56.7	22.5	0.141
	Alpha	-34.1	-16.8	-4.2	4.4	22.6				
	IV Spread	-12.8	-3.7	-0.9	1.4	9.7				
Decile 10	Return	8.8	24.9	34.6	69.7	74.8	66.0	71.3	27.4	0.261
	Alpha	-52.5	-34.2	-23.0	5.3	18.8				
	IV Spread	-15.1	-4.1	-0.7	2.0	12.3				
Banking	Return	38.9	47.2	52.9	56.7	68.7	29.8	38.9	9.3	0.078
	Alpha	-9.9	3.1	11.8	14.6	29.0				
	IV Spread	-5.9	-2.1	-0.7	0.5	3.4				