Speculation or Hedging?
— Options Trading Prior to FOMC Announcements

George J. Jiang and Guanzhong Pan ☆

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☆ George J. Jiang is the Gary P. Brinson Chair of Investment Management in the Department of Finance and Management Science, Carson College of Business, Washington State University, Pullman, WA 99164; email george.jiang@wsu.edu; tel. (509) 335-4474; fax (509) 335-3857. Guanzhong Pan is from the Finance School, Yunnan University of Finance and Economics, Kunming, Yunnan, China; email panguanzhong@126.com; tel. 0871 65192609. We thank Hart Wang, and seminar participants at Washington State University for helpful comments and suggestions.

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Abstract

This paper investigates options trading activity prior to FOMC announcements. We find evidence that informed traders use options to speculate on their private information for the upcoming FOMC announcements. Specifically, abnormal trading volume of call options on S&P500 index during the pre-announcement window positively predicts post-announcement index returns, and this predictability mainly comes from near-the-money call options. Moreover, we further breakdown trading volume based on the direction of trades and show that buyer-initiated call option trading volume positively predicts post-announcement index returns. We find no evidence that investors use options to hedge post-announcement market uncertainty.

Keywords: FOMC announcement; Option trading; Speculation; Hedging

JEL Classification: G12; G14; E5

I. Introduction

The Federal Open Market Committee (FOMC) announcement is an important event that not only attracts great attention of market participants and the media but also has significant effect on market returns. We show that during the one-hour post-FOMC announcement window, the return on S&P500 index ranges from -2.28% to 2.50% over the period of 2004 to 2016. This is evidence that the FOMC announcement not only contains important information on equity valuation but also presents great risk or uncertainty to investors.

Interestingly, we also observe substantial increase in options premium prior to FOMC announcements. The average VIX level starts to increase three trading days before the FOMC announcement, peaking off the day before announcement. As VIX measures the implied volatility of option prices and high VIX corresponds to high option premium, the increase of VIX level during the pre-FOMC announcement window raises two important questions: Do investors trade options to speculate on the information of the upcoming FOMC announcement? Do investors trade options to hedge the uncertainty of the upcoming FOMC announcement?

Options are often used by traders for the purpose of speculation and hedging. There is a voluminous literature and textbook in finance discussing the role of options playing in price discovery and hedging, such as Easley, O'Hara, and Srinivas (1998), Hull (2006), Pan and Poteshman (2006), Roll, Schwartz, and Subrahmanyam (2010), Xing, Zhang, and Zhao (2010), Ge, Lin, and Pearson (2016), Ryu and Yang (2018), Bergsma et al. (2020).

The extant literature documents abnormal trading activity in option market around important corporate events, such as earnings announcement (Amin and Lee, 1997), M&A (Cao, Chen, and Griffin, 2005; Augustin, Brenner, Grass, and Subrahmanyam, 2018; Cremers, Fodor,

Muravyev, and Weinbaum, 2019), share repurchase announcement (Hao, 2016), dividend change announcement (Zhang, 2018), and a sample of unscheduled corporate announcements related to M&As, seasoned equity offerings, stock repurchases, dividend initiations and terminations (Baruch, Panayides, and Venkataraman, 2017).

In this paper, we examine option trading in anticipation of an important macroeconomic event, the FOMC announcement. We find informed traders use option to speculate on their private information. Specifically, abnormal trading volume of call options on S&P500 index during the pre-announcement window of the FOMC announcement positively predicts post-announcement index return, and this predictability mainly comes from near-the-money (NTM) call option. The finding is consistent with evience docunted in Bernile, Hu, and Tang (2016) that there is informed trading during news embargoes of (30 minutes before) the FOMC announcements. Specifically, the E-mini S&P 500 futures' average abnormal order imbalance predicts subsequent policy surprises. Our finding is also consistent with Chordia et al. (2021) who find that weekly index put order flow on the International Securities Exchange positively predicts weekly S&P 500 index returns, and this result is strong in high VIX periods and in periods following major pre-scheduled macroeconomic announcements, e.g., FOMC announcements. Moreover, we further breakdown trading volume based on the direction of trade and show buyer-initiated call option trading volume positively predicts post-announcement index return. However, we find no evidence of investors using options to hedge post-FOMC announcement market uncertainty.

The remainder of this paper is organized as follows. Section II is literature review and hypotheses development; section III describes data used in empirical analysis and summary statistics; section IV specifies our empirical tests and presents main results; section V concludes the paper.

II. Literature review and hypotheses development

The literature presents that informed investors use option market to speculate, both theoretically and empirically. Easley, O'Hara, and Srinivas (1998) develop a sequential trade model with multiple trading venues in which investors can trade in both stock and option markets. Some traders are informed and other traders are uninformed, and risk-neutral competitive market makers coordinate the transactions. Easley, O'Hara, and Srinivas (1998) derive a "pooling equilibrium" in which informed traders trade in the option market when the liquidity in the stock market is low or the fraction of informed traders is high. Basically, their model predicts that when investors can trade both in stock and option markets, because of high leverage of options, informed investors with financial constraint prefer option to speculate.

Empirically, the literature documents that various option trading variables can predict future stock returns. Signed option trading volume (Amin and Lee, 1997; Easley, O'Hara, and Srinivas, 1998), put-call ratios from option volume initiated by buyers to open new positions (Pan and Poteshman, 2006), implied volatility spreads (Bali and Hovakimian, 2009, Cremers and Weinbaum, 2010), Bali and Murray (2013), Cremers and Weinbaum (2010), the ratio of option trading volume to stock trading volume (O/S) (Roll, Schwartz, Subrahmanyam, 2010).

The literature also documents intensified option trading activity before (or around) information relevant events. Amin and Lee (1997) find option trading volume increases four days before quarterly earnings announcement, the direction of this preannouncement trading predicts subsequent earnings news, and there are informed option traders whose trading help incorporated their private information into stock price. They also find informed traders not necessarily trade options with greatest leverage, because they trade off the benefit of greater leverage against the

higher costs from bid-ask spreads and the risk of detection. Augustin, Brenner, Grass, and Subrahmanyam (2018) document the pervasiveness of informed trading activity in target companies' equity options before the announcement of takeovers, such that 25% of all takeovers have positive abnormal volumes and which are greater for short-dated out-of-the-money calls. Zhang (2018) find a positive (negative) association between pre-announcement abnormal implied volatility spread and cumulative abnormal stock returns around dividend change announcement.

If informed traders use options to speculate, then their trading activities contain information and can predict future stock returns. When informed investors have positive private information about future stock prices, they can either buy call option or sell put option to speculate on their private information. One important character of options is that their payoff functions are asymmetric when the underlying stock price goes up or goes down. The payoff function of a call option has no upper bound, and the holder of a call option in theory potentially have infinite large payoff when the underlying stock price goes up. And the payoff function of a call option has a low bound, that is the call option premium. The greatest loss that a call option holder can generate is the call option premium. On the other hand, the payoff function of has an upper bound and the greatest payoff a seller of put option can get is the option premium. However, the potential loss of a put option can be very large, as large as the strike price when the underlying stock price goes down to zero. Therefore, informed investors prefer to buy call option to speculate when they have positive information about future stock returns. When speculators buy call option, ceteris paribus, call option trading volume will increase. So we expect abnormal trading volume of call option positively predicts post-FOMC announcement returns. As we have seen in Amin and Lee (1997), informed traders trade off the benefit of greater leverage against the higher costs from bid-ask spreads and the risk of detection. The market for out-of-money (OTM) options is less liquid, has

wider bid-ask spread and high transaction costs. So when breakdown options based on moneyness, we expect speculators use near-the-money (NTM) option to trade, and hence abnormal trading volume of NTM call option positively predicts post-FOMC announcement returns. Further, as in classical sequential trading model such as Glosten and Milgrom (1985), Easley, O'Hara, and Srinivas (1998), informed investors actively trade based on their private information, that is, investors with positive information tend to buy at the ask price and investors with negative information tend to sell at the bid price. Hence the direction of a trade (buyer-initiated or buyer-initiated) contains information about future asset prices. Under our setting when informed investors have positive information about future stock price, we expect the abnormal trading volume of buyer-initiated call option positively, even stronger than non-differentiated call option trading volume, predicts post-FOMC announcement returns.

When informed investors have negative private information about future stock prices, they can either buy put option or sell call option to speculate on their private information. However, index put options are expensive, especially the out-of-the-money (OTM) index put options. As Bollen and Whaley (2004) point out, the index implied volatility function decreases monotonically across exercise prices since October 1987. Basically, it says since the market crash of 1987, market becomes more worrisome about future market crash and the demand for the market crash insurance, put options, especially OTM put options, dramatically increases. On the other hand, the supply of put options is limited because limits of arbitrage and hence market maker can only produce enough put option with high costs. Combining these two factors, the put option price since 1987 is much higher than before. Under our FOMC announcement setting, this event is short-term of only 2 to 3 days, the magnitude of index drop is unlikely very large, hence the price of index put option may

be high enough to deter informed investors to use it to speculate. So we expect the abnormal trading volume of put option has no predictive power for post-FOMC announcement returns.

Below we summarize above analysis into our testable hypothesis 1:

H1: If informed traders use options to speculate, then abnormal trading volume of options predicts post-FOMC announcement returns.

- H1a: More conservative informed traders mainly use near-the-money options to speculate because of liquidity concerns.
- H1b: In particular, buyer-initiated options have stronger predictability.

Due to low transaction costs of options, portfolio managers often use option to hedge risk of portfolio. When investors expect future market uncertainty is high, they are going to buy option to hedge the risk of their portfolio. So we expect abnormal trading volume of options is positively associated with future market uncertainty after the announcement when investors use options to hedge.

Below we summarize above analysis into our testable hypothesis 2:

H2: If investors hedge uncertainty in the upcoming announcement, then abnormal trading volume of options predicts uncertainty of the announcement.

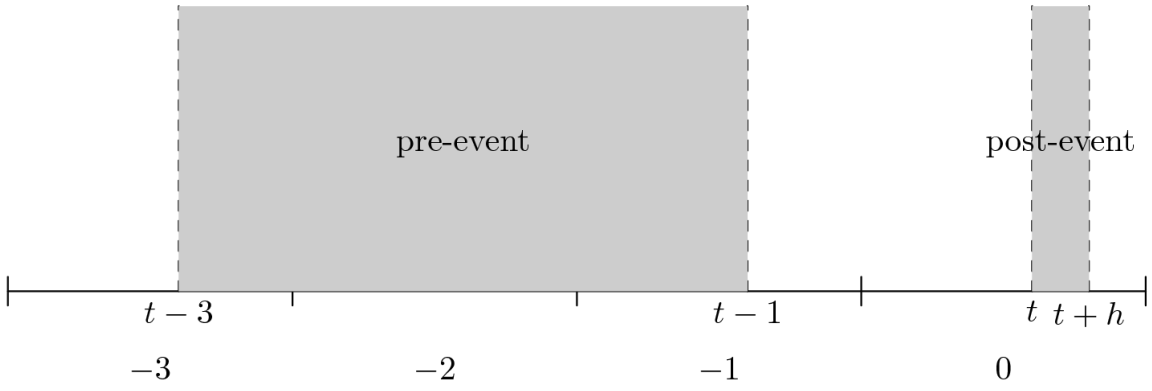
III. Data and methodology

We use data from several sources in our empirical tests. We obtain options trade data from www.cboe.com. Included with each trade is the option type, expiration, and strike, the trade price and size, the exchange where the trade printed, the NBBO quote and depth, the underlying bid and

ask, and each of the individual exchange markets. Other data used include: intraday returns of S&P 500 index and the CBOE volatility index (VIX) from www.tickdata.com, trade and quote data on S&P500 tracking ETF (SPY) from TAQ database. Our sample period spans from 2004 to December 2016.

We examine the effects of option trading around the FOMC announcement. Below in Exhibit 1, we illustrate the event window in our analysis: We examine four consecutive trading days around the FOMC announcement, the announcement day 0, and three trading days preceding it, -3, -2 and -1; We examine intra-day market activities around FOMC announcement, the announcement time is *t*, 1 hour post-announcement time is *t*+*h*, 1 trading day prior to the announcement time *t* is *t*-1, and 3 trading days prior to the announcement time *t* is *t*-3. Our pre-announcement window is from *t*-3 to *t*-1, and post-announcement window is from *t* to *t*+*h*.

Exhibit 1: Event Window



We observe a distinguished pattern of VIX change around the FOMC announcement window. In Figure 1, we plot the average VIX level of four consecutive days before the FOMC announcement, three days before the announcement time, the VIX starts to increase from the level of 19.2, gradually goes up through the second trading day before the announcement, finally around the open of the first trading day before the announcement, arrives the highest point at 19.8, and

then goes down gradually as the uncertainty resolved to the lowest point below 19.0 1-hour post the announcement.

Basically, our empirical tests run two types of regression, in one the dependent variable is 1-hour post-announcement return, in the other the dependent variable is 1-hour post-announcement VIX level change, and the dependent variables are various types of abnormal option trading volume. The dependent variable 1-hour post announcement log return on S&P 500 index, *Ret_1h*, is defined by $Ret\_1h = \ln P_{t+h} - \ln P_t$, where t is the FOMC announcement time, P_t is the S&P 500 index level at the FOMC announcement time, P_{t+h} is the S&P 500 index level one hour post the FOMC announcement time.

The dependent variable, 1-hour post announcement VIX level change, *dvix1h*, is defined by $dvix1h = VIX_{t+h} - VIX_t$, where VIX_t is the VIX level at the FOMC announcement time, VIX_{t+h} is the VIX level one hour post the FOMC announcement time.

Table I reports summary statistics of these two dependent variables used in our empirical analysis. We see from Table I that the mean return on S&P 500 index one hour post the FOMC announcement is 15 basis points, being 24.57% annualized return; the VIX level drops about 0.45 points on average one hour post the FOMC announcement.

We focus on short-term options of which time-to-maturity is less than 37 days, which is the largest maturity CBOE used to calculate VIX. We construct abnormal option trading volumes by the following procedure. First, we compute abnormal trading volumes (ATVs) of calls and puts (C&P) relative to previous five trading days.

To test informativeness of option trading based on moneyness, we break down trading volume into near-the-money (NTM) and out-of-the-money (OTM) trading volumes. For call options, we classify

- NTM option when $K/S < 1.10$ and OTM option when $K/S \geq 1.10$.

For put options, we classify

- OTM option when $K/S < 1.10$ and NTM option when $K/S \geq 1.10$.

Then, we use Lee and Ready (2001) algorithm to identify buyer-initiated and seller-initiated transactions for call and put option contracts. Specifically, we first use a quote test first, then a tick test. In the quote test, if the price of an option trade is higher than the midpoint of the NBBO bid and ask, then the trade is classified as buyer-initiated. If the price is lower than the midpoint, the trade is classified as seller-initiated. When they are equal, the tick test is utilized. In the tick test, if the price is higher than the previous price, it is classified as buyer-initiated and if it is lower, then the trade is classified as seller-initiated. Other cases are considered as non-determined.

Then we compute abnormal trading volumes for each type of trades. So in our finest breakdown of option trading volume, we have 2×2×2=8 categories of abnormal trading volume (call or put, NTM or OTM, and buyer or seller-initiated). For example, we have 2 types of Seller initiated Call abnormal trading volumes: SC(NTM) and SC(OTM).

Table II reports summary statistics of independent variables used in our empirical analysis, various breakdowns of abnormal trading volumes of S&P 500 index option, and a control variable, the VIX level one trading day before the FOMC announcement time, *VIX*. We see from Table II that on average, during the pre-announcement trading window, $[t-3, t-1)$, option's trading

volume drops about 20.49 million dollars relative to previous five trading days. We have seen in Lucca and Moench (2015) that in stock market, trading volume actually drops one trading day immediately before the FOMC announcement, that is, during the pre-announcement trading window, $[t-1, t)$. So option market moves earlier than stock market in anticipation of the FOMC announcement. Call option's trading volume (C) and put option's trading volume (P) drop with similar magnitude, both are about 10 million dollars. When we break down option's trading volume based on moneyness, the big proportion of both call option and put option's trading volume drop come from near-the-money (NTM) option's trading: Near-the-money call option trading volume C(NTM) drops 9.89 million dollars, whereas out-of-the-money call option trading volume C(OTM) only drops 0.28 million dollars; put option's trading has similar pattern, near-the-money put option trading volume P(NTM) drops 8.97 million dollars, whereas out-of-the-money call option trading volume P(OTM) only drops 1.36 million dollars. We also break down option's trading volume based on buyer-initiated or seller-initiated trading classified by Lee and Ready (1991) algorithm. We see from Table II that for both call and put options, the buyer-initiated and seller-initiated abnormal trading volumes have similar pattern: Buyer-initiated call (BC) drops 4.72 million dollars, comparable to seller-initiated call (SC)'s 5.44 million dollars; buyer-initiated put (BP) drops 5.25 million dollars, comparable to seller-initiated put (SP)'s 5.08 million dollars. Our further breakdowns of option's trading volume based on moneyness and buyer (seller) initiated trading also show us the patterns of abnormal option trading volume: The trading volume drops of call option and put option are similar, of buyer (seller) initiated trading are similar, but of moneyness are quite different, most of the drop of trading volume comes from near-the-money option's trading.

IV. Empirical tests and results

A. Tests based on abnormal trading volume

To test H1, if option trading is due to speculation, then ATVs correctly predict the announcement return, we run the following regressions:

$$Ret1h_{[t,t+h)} = \alpha + \beta ATVs_{[t-3,\, t-1)} + \epsilon_t, \tag{1}$$

$$Ret1h_{[t,t+h)} = \alpha + \beta ATVs_{[t-3,\, t-1)} + \gamma VIX_{t-1} + \epsilon_t, \tag{2}$$

We control for the market uncertainty at 1-day before the FOMC announcement time in the above regression, and we use VIX level as a measure of uncertainty.

Table III reports the regression results of testing H1 of speculation. The results in Table III Panel A suggest that two to three days in anticipation of FOMC announcement, there is informed trading in option market and informed traders use call options to speculate. In column (2), when we regress 1-hour post-announcement return on abnormal pre-announcement call option trading volume (denoted by C), controlling for risk measured by VIX level (denoted by *VIX*), the estimated coefficient is 0.02, significant at 5% level. Economically, this says if pre-announcement trading volume of call options increases 1 million dollars, then 1-hour post-announcement return will on average increase by 2 basis points, or 32.76% annualized return. The result in column (4) of put option is not significant, which provides no evidence that informed traders use put options to speculate.

To explore what types of call option are used by speculators, we further break down call options based on moneyness into two categories, near-the-money (NTM) call and out-of-the-money (OTM) call. In column (6), when we regress 1-hour post-announcement return on abnormal pre-announcement NTM call option trading volume (denoted by C(NTM)), controlling for risk

measured by VIX level (denoted by VIX), the estimated coefficient is 0.021, significant at 5% level. The result is statistically and economically similar to the result of call option, which suggests that the informativeness of call option trading is mainly driven by near-the-money call option. In column (8), when we regress 1-hour post-announcement return on abnormal pre-announcement OTM call option trading volume (denoted by C(OTM)), controlling for risk measured by VIX level (denoted by VIX), the estimated coefficient is -0.693, significant at 1% level. This result is opposite to the prediction of speculation. Examining further into the results, the sign of *VIX* is changed to be negative and insignificant, which suggests C(OTM) is correlated with risk measure *VIX*. The result show decrease in C(OTM) predicts high 1-hour post-announcement return, possibly because high uncertainty deters traders in OTM call option. Figure 2 plots the time series of daily VIX level during our sample period from 2004 to 2016, with the shaded area covering the financial crisis period of 2008 to 2009. We see from Figure 2 that during financial crisis of 2008 to 2009, the VIX level is as high as 80, indicating market uncertainty is historically high. Because our sample covers this financial crisis period, we do the same analysis by excluding financial crisis period of 2008 to 2009 and the results are reported in Table III Panel B. The results of call option and NTM call remain: The coefficient estimate of C is 0.016 and significant at 10% level and the coefficient estimate of C(NTM) is also 0.016 and significant at 10% level. However, the effect of OTM call is gone: The coefficient estimate of C(OTM) is not significant any more. The results in Table III suggest that the informativeness of NTM call is robust, whether we exclude financial crisis period or not, but the negative association between OTM call option trading and 1-hour post-announcement return is mainly driven by the extreme high uncertainty during the financial crisis of 2008 to 2009.

To test H2, option traders' hedging demand is high when expected announcement uncertainty is high, we run the following regressions:

$$dvix1h_{[t,t+h)} = \alpha + \beta ATVs_{[t-3,\,t-1)} + \epsilon_t, \tag{3}$$

$$dvix1h_{[t,t+h)} = \alpha + \beta ATVs_{[t-3,\,t-1)} + \gamma VIX_{t-1} + \epsilon_t, \tag{4}$$

Similarly, we also control for the market uncertainty at 1-day before the FOMC announcement time in the above regression.

Table IV reports the regression results of testing H2 of hedging. Table IV Panel A reports the results of full sample from 2004 to 2016, and Panel B the results of excluding financial crisis period of 2008 to 2009. In column (2) of Panel A, when we regress 1-hour post-announcement VIX level change (denoted by *dvix1h*) on abnormal pre-announcement call option trading volume (denoted by C), controlling for risk measured by VIX level (denoted by *VIX*), the estimated coefficient is -0.02, significant at 10% level. The results in column (6) suggests this effect mainly comes from OTM call option. Although the coefficient estimate of C is significant, its sign is negative, contrary to the implication of hedging in H2. Therefore, the results of call option trading provide no evidence that traders use call option to hedge post-announcement risk. In table IV Panel A, the results of put option trading have no significance, so neither there is evidence that traders use put option to hedge post-announcement risk. In Table IV Panel B, the significance of call option is gone, and no significance for put option, which provide no evidence of trading using option to hedge post-announcement risk.

B. Tests based on directional trades

To explore whether active-side trades play a role in speculation or hedging, we further break down option's trading into buyer-initiated or seller-initiated trades according to Lee and Ready (1991) algorithm.

To test speculation base on directional trading, we run the following regression:

$$Ret_{[t,t+h)} = \alpha + \beta ATV\_B_{[t-3,\,t-1)} + \gamma VIX_{t-1} + \epsilon_t \quad (5)$$

$$Ret_{[t,t+h)} = \alpha + \beta ATV\_S_{[t-3,\,t-1)} + \gamma VIX_{t-1} + \epsilon_t \quad (6)$$

where $ATV\_B(S)_{[t-3,\,t-1)}$ denotes buyer (seller)-initiated abnormal trading volume.

Table V reports the regression results of testing H1 of speculation considering active-side trades. Table V Panel A reports the results of full sample from 2004 to 2016, and Panel B the results of excluding financial crisis period of 2008 to 2009. In column (1) of Panel A, when we regress 1-hour post-announcement return on abnormal pre-announcement buyer-initiated call option trading volume (denoted by BC), controlling for risk measured by VIX level (denoted by *VIX*), the estimated coefficient is 0.046, significant at 5% level. Economically, this says if pre-announcement buyer-initiated trading volume of call options increases 1 million dollars, then 1-hour post-announcement return will on average increase by 4.6 basis points. This result is consistent with the prediction in H1. And the result is stronger when we have a finer breakdown rather than only call option: The magnitude of coefficient estimate is more than doubled, from 0.02 in Table III Panel A column (2) to 0.046 in Table III Panel B column (1), and adjusted R^2 increases from 6.7% to 8.2%. The result in column (3) suggests this effect mainly comes from NTM call option, consistent with Table III Panel A column (6). The results in column (5) and column (11) are also significant, but their signs are contrary to predictions in H1. Specifically, in column (5), the coefficient estimate of buyer-initiated, OTM call (denoted by BC(OTM)) is -1.203 and

significant at 1% level; in column (11), the coefficient estimate of buyer-initiated, OTM put (denoted by BP(OTM)) is 0.295 and significant at 5% level. In Panel B when financial crisis period is excluded, the positive significance of BC and BC(NTM) remains, but the significance of BC(OTM) and BP(OTM) disappear. These results suggest the contrary predictions of OTM options about informed trading are driven by the financial crisis.

To test hedging base on directional trading, we run the following regressions:

$$dvix_{[t,t+h)} = \alpha + \beta ATV\_B_{[t-3,\,t-1)} + \gamma VIX_{t-1} + \epsilon_t \quad (7)$$

$$dvix_{[t,t+h)} = \alpha + \beta ATV\_S_{[t-3,\,t-1)} + \gamma VIX_{t-1} + \epsilon_t \quad (8)$$

where $ATV\_B(S)_{[t-3,\,t-1)}$ denotes buyer (seller)-initiated abnormal trading volume.

Table VI reports the regression results of testing H2 of hedging considering active-side trades. Table VI Panel A reports the results of full sample from 2004 to 2016, and Panel B the results of excluding financial crisis period of 2008 to 2009. Column (1) and (3) show the negative association between pre-announcement abnormal trading volume on call option mainly comes from buyer-initiated and in particular NTM call option. This results remain even after we exclude the financial crisis period of 2008 to 2009. In Panel A column (5), the estimated coefficient of BC(OTM) is 0.981 and significant at 10% level. There is a weak evidence of traders buy out-of-the-money call options to hedge. However, when we exclude the financial crisis period of 2008 to 2009 in Panel B, this effect is gone.

C. Joint test: Reverse Regressions

As we see from previous sections, certain types of abnormal option trading volume can predict both post-FOMC announcement return and VIX level change. A question then arises: What

information do informed traders use? Is it information about future return or volatility? To answer this question, we do a joint test, i.e., we run the following reverse regressions:

$$ATV_{[t-3,\,t-1)} = \alpha + \beta Ret_{[t,t+h)} + \epsilon_t \tag{9}$$

$$ATV_{[t-3,\,t-1)} = \alpha + \beta dvix_{[t,t+h)} + \epsilon_t \tag{10}$$

$$ATV_{[t-3,\,t-1)} = \alpha + \beta_1 Ret_{[t,t+h)} + \beta_2 dvix_{[t,t+h)} + \epsilon_t \tag{11}$$

where the dependent variable *ATV* is an abnormal option trading volume which significantly predicts post-announcement return or VIX level change in regressions (2) and (4). The use of reverse regression is introduced in econometrics textbooks, such as Maddala (1978) and Leamer (1978).

First, we identity the ATVs which significantly predict post-FOMC announcement return *Ret_1h* and/or VIX level change *dvix1h*, C, C(NTM), BC, BC(NTM), BC(OTM), BP(OTM). Then we run regression (11) for each of these ATVs. The results of regression in (11) are reported in Table VII. We see in Panel A of whole sample when throw both post-FOMC announcement return *Ret_1h* and VIX level change *dvix1h* into the regression, only the association between *Ret_1h* and abnormal option trading volume is significant, but the association between *dvix1h* and abnormal option trading volume is not significant. These results provide further evidence of speculation but no of hedging. However, in Panel B of excluding financial crisis period of 2008 to 2009, all the significant results are gone. We provide further evidence by doing Vuong (1989)'s test. Vuong's test is a likelihood ratio test of distinguishable models, which can be applied to both nested and nonnested models. In our setting, model (11) nests both model (9) and model (10). The null hypothesis of Vuong's test is the large model fits as well as the small model, and the alternative hypothesis is the large model fits better than the small model. The p-value of the test measure the

distance of the small model to the large model, high p-value means the small model is close to the large model. We report p-values of Vuong's test in Table VIII. We see in Panel A of whole sample most of p-values of model (9) with *Ret_1h* as explanatory variable are greater than model (10) with *dvix1h* as explanatory variable, which shows model (9) is closer to model (11) than model (10) for most of the ATV variables. We get similar results in Panel B of excluding financial crisis period of 2008 to 2009. Intuitively, these results indicate post-announcement return is better predicted by ATVs than volatility change, and informed traders are more inclined to use their private information to speculate than hedge.

V. Conclusion

This paper investigates options trading activity prior to FOMC announcements. We observe VIX start to increase three trading days prior to the FOMC announcement, which indicates option market moves before the stock market, because stock market index starts to drift upward and trading volume to decrease one trading day prior. We find informed traders use option to speculate on their private information. Specifically, abnormal trading volume of call option on S&P500 index three to two trading days prior to the FOMC announcement positively predicts post-announcement index return, and this predictability mainly comes from NTM call option and from buyer-initiated call option trading when we further breakdown trading volume based on the direction of trade. We find no evidence of investors using options to hedge post-FOMC announcement market risk.

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Table I: Summary Statistics of Post FOMC Announcement Return and VIX Level Change

This table reports the summary statistics of our dependent variables. The dependent variable 1-hour post announcement log return on S&P 500 index, *Ret_1h*, is defined by $Ret\_1h = \ln P_{t+h} - \ln P_t$, where t is the FOMC announcement time, P_t is the S&P 500 index level at the FOMC announcement time, P_{t+h} is the S&P 500 index level one hour post the FOMC announcement time. The dependent variable, 1-hour post announcement VIX level change, *dvix1h*, is defined by $dvix1h = VIX_{t+h} - VIX_t$, where VIX_t is the VIX level at the FOMC announcement time, VIX_{t+h} is the VIX level one hour post the FOMC announcement time.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Ret_1h	104	0.15	0.72	-2.28	-0.20	0.16	0.47	2.50
dvix1h	104	-0.45	1.02	-4.23	-0.69	-0.26	0.07	2.64

Table II: Summary Statistics of Pre-FOMC Announcement VIX and Option Abnormal Trading Volumes

This table reports the summary statistics of our independent variables, control variable VIX and various abnormal option trading volumes. VIX is the VIX level at 1-day before the FOMC announcement time, a measure of market uncertain. We compute abnormal trading volumes of calls and puts (C&P) relative to previous five trading days. For call options, we classify NTM option when K/S < 1.10 and OTM option when K/S ≥1.10. For put options, we classify OTM option when K/S < 1.10 and NTM option when K/S ≥1.10. We use Lee and Ready (2001) algorithm to identify buyer-initiated and seller-initiated transactions for call and put option contracts. Specifically, we first use a quote test first, then a tick test. In the quote test, if the price of an option trade is higher than the midpoint of the NBBO bid and ask, then the trade is classified as buyer-initiated. If the price is lower than the midpoint, the trade is classified as seller-initiated. When they are equal, the tick test is utilized. In the tick test, if the price is higher than the previous price, it is classified as buyer-initiated and if it is lower, then the trade is classified as seller-initiated. Other cases are considered as non-determined. Then we compute abnormal trading volumes for each type of trades. So in our finest breakdown of option trading volume, we have 2×2×2=8 categories of abnormal trading volume (call or put, NTM or OTM, and buyer or seller-initiated), denoted as BC(NTM), SC(NTM), BC(OTM), SC(OTM), BP(NTM), SP (NTM), BP (OTM), SP (OTM).

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
VIX	104	19.69	9.61	11.02	13.66	16.69	21.71	74.39
C&P	104	-20.49	16.00	-95.41	-24.70	-17.61	-9.48	0.38
C	104	-10.16	7.60	-33.41	-13.14	-8.75	-4.49	3.76
P	104	-10.33	10.28	-63.55	-12.43	-8.29	-3.94	5.16
C(NTM)	104	-9.89	7.47	-32.62	-12.96	-8.23	-4.49	3.85
C(OTM)	104	-0.28	0.49	-3.00	-0.30	-0.10	-0.02	0.00
P(NTM)	104	-8.97	9.49	-56.52	-10.73	-7.09	-3.96	5.82
P(OTM)	104	-1.36	1.11	-7.03	-1.91	-1.18	-0.51	0.18
BC(NTM)	104	-4.57	3.84	-15.94	-6.11	-3.77	-2.22	8.14
SC(NTM)	104	-5.32	4.53	-23.40	-6.45	-4.22	-2.10	-0.43
BC(OTM)	104	-0.15	0.31	-2.00	-0.20	-0.10	-0.01	0.00
SC(OTM)	104	-0.12	0.20	-1.00	-0.20	-0.10	0.00	0.00
BP(NTM)	104	-4.55	4.73	-28.86	-5.24	-3.57	-1.97	1.56
SP(NTM)	104	-4.42	4.91	-27.66	-5.15	-3.47	-1.87	4.45
BP(OTM)	104	-0.70	0.60	-3.99	-0.99	-0.54	-0.25	0.17
SP(OTM)	104	-0.66	0.56	-3.05	-0.88	-0.54	-0.27	0.01

Table III: The Predictability of Option Trading Volumes for Post FOMC Announcement Returns

This table reports the results of testing whether informed investors speculate by trading options. The test is done by regressing 1-hour post-FOMC announcement return, Ret_1h, on various abnormal option trading volumes. Abnormal option trading volumes on pre-announcement window [t-3, t-1] are calculated by the specific type of option trading volume minus the preceding 5 trading days' average trading volume. The abnormal trading volume of call option is denoted by C, put option by P, near-the-money call by C(NTM), out-of-the-money call by C(OTM), near-the-money put by P(NTM), out-of-the-money put by P(OTM), and the control variable is the VIX level 1-day prior to the announcement time, denoted by VIX. The t-statistics are reported in the parentheses which are calculated by using Newey-West standard errors. Panel A reports the regression results of full sample period from 2004 to 2016, and Panel B reports the regression results of excluding financial crisis period of 2008 to 2009.

Panel A: The regression results of full sample period: 2004 to 2016

	Dependent variable: Ret_1h											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
C	0.012*	0.020**										
	(0.007)	(0.009)										
P			-0.005	0.005								
			(0.008)	(0.011)								
C(NTM)					0.015**	0.021**						
					(0.007)	(0.009)						
C(OTM)							-0.434***	-0.693**				
							(0.094)	(0.283)				
P(NTM)									-0.005	0.005		
									(0.008)	(0.011)		
P(OTM)											-0.047	0.141
											(0.075)	(0.105)
VIX		0.020**		0.019		0.020**		-0.015		0.018		0.028*
		(0.009)		(0.012)		(0.009)		(0.015)		(0.012)		(0.015)
Constant	0.275**	-0.051	0.099	-0.170	0.294**	-0.034	0.030	0.259	0.104	-0.168	0.087	-0.216
	(0.118)	(0.168)	(0.096)	(0.173)	(0.125)	(0.167)	(0.064)	(0.224)	(0.094)	(0.171)	(0.109)	(0.197)
Observations	104	104	104	104	104	104	104	104	104	104	104	104
Adjusted R^2	0.007	0.067	-0.005	0.029	0.013	0.070	0.079	0.080	-0.005	0.028	-0.005	0.046

Note: *p<0.1; **p<0.05; ***p<0.01

Panel B: The regression results of excluding financial crisis period of 2008 to 2009

	Dependent variable: Ret_1h											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
C	0.016*	0.016*										
	(0.009)	(0.009)										
P			0.006	0.005								
			(0.009)	(0.009)								
C(NTM)					0.017*	0.016*						
					(0.009)	(0.009)						
C(OTM)							0.147	-0.017				
							(0.382)	(0.332)				
P(NTM)									0.006	0.005		
									(0.009)	(0.009)		
P(OTM)											0.059	0.046
											(0.088)	(0.095)
VIX		-0.003		-0.006		-0.004		-0.008		-0.006		-0.004
		(0.012)		(0.012)		(0.012)		(0.011)		(0.012)		(0.012)
Constant	0.255**	0.307	0.149	0.233	0.255**	0.311	0.118	0.235	0.143	0.234	0.165	0.215
	(0.129)	(0.246)	(0.106)	(0.232)	(0.128)	(0.246)	(0.088)	(0.206)	(0.099)	(0.232)	(0.143)	(0.222)
Observations	88	88	88	88	88	88	88	88	88	88	88	88
Adjusted R^2	0.024	0.013	-0.006	-0.016	0.024	0.014	-0.010	-0.019	-0.006	-0.016	-0.005	-0.016

Note: *p<0.1; **p<0.05; ***p<0.01

Table IV: The Predictability of Option Trading Volumes for Post FOMC Announcement VIX Level Change

This table reports the results of testing whether investors hedge post-FOMC announcement risk by trading options. The test is done by regressing 1-hour post-FOMC VIX level change, dvix1h, on various abnormal option trading volumes. Abnormal option trading volumes on pre-announcement window [t-3, t-1] are calculated by the specific type of option trading volume minus the preceding 5 trading days' average trading volume. The abnormal trading volume of call option is denoted by C, put option by P, near-the-money call by C(NTM), out-of-the-money call by C(OTM), near-the-money put by P(NTM), out-of-the-money put by P(OTM), and the control variable is the VIX level 1-day prior to the announcement time, denoted by vix_1. The t-statistics are reported in the parentheses which are calculated by using Newey-West standard errors. Panel A reports the regression results of full sample period from 2004 to 2016, and Panel B reports the regression results of excluding financial crisis period of 2008 to 2009.

Panel A: The regression results of full sample period: 2004 to 2016

	Dependent variable: dvix1h											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
C	-0.003	-0.020*										
	(0.014)	(0.010)										
P			0.027*	0.008								
			(0.014)	(0.013)								
C(NTM)					-0.007	-0.020**						
					(0.013)	(0.010)						
C(OTM)							0.753***	0.331				
							(0.174)	(0.313)				
P(NTM)									0.028*	0.010		
									(0.015)	(0.013)		
P(OTM)											0.197	-0.157
											(0.145)	(0.124)
VIX		-0.044***		-0.035***		-0.043***		-0.025		-0.034***		-0.054***
		(0.013)		(0.011)		(0.013)		(0.021)		(0.011)		(0.017)
Constant	-0.480***	0.224	-0.171	0.321	-0.513***	0.209	-0.238***	0.134	-0.190	0.322	-0.178	0.395*
	(0.179)	(0.226)	(0.127)	(0.196)	(0.178)	(0.227)	(0.083)	(0.304)	(0.118)	(0.196)	(0.176)	(0.228)
Observations	104	104	104	104	104	104	104	104	104	104	104	104
Adjusted R^2	-0.009	0.143	0.063	0.127	-0.007	0.144	0.124	0.129	0.061	0.129	0.037	0.135

Note: *p<0.1; **p<0.05; ***p<0.01

Panel B: The regression results of excluding financial crisis period of 2008 to 2009

	Dependent variable: dvix1h											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
C	-0.020	-0.024										
	(0.014)	(0.016)										
P			0.004	-0.001								
			(0.012)	(0.011)								
C(NTM)					-0.020	-0.024						
					(0.014)	(0.016)						
C(OTM)							0.372	-0.118				
							(0.522)	(0.556)				
P(NTM)									0.005	0.0002		
									(0.013)	(0.012)		
P(OTM)											-0.025	-0.145
											(0.131)	(0.148)
VIX		-0.029		-0.023		-0.028		-0.024		-0.022		-0.035
		(0.023)		(0.021)		(0.022)		(0.021)		(0.021)		(0.023)
Constant	-0.550***	-0.099	-0.328**	0.015	-0.552***	-0.105	-0.310***	0.039	-0.325***	0.015	-0.390**	0.069
	(0.211)	(0.326)	(0.130)	(0.327)	(0.211)	(0.324)	(0.101)	(0.318)	(0.121)	(0.325)	(0.190)	(0.342)
Observations	88	88	88	88	88	88	88	88	88	88	88	88
Adjusted R^2	0.013	0.030	-0.010	-0.006	0.014	0.030	-0.007	-0.006	-0.010	-0.006	-0.011	0.007

Note: *p<0.1; **p<0.05; ***p<0.01

Table V: The Predictability of Directional Option Trading Volumes for Post FOMC Announcement Returns

This table reports the results of testing whether informed investors speculate by trading options based on directional trades. The test is done by regressing 1-hour post-FOMC announcement return, Ret_1h, on various abnormal option trading volumes classified as buyer-initiated or seller-initiated by Lee and Ready (1991) algorithm. Abnormal option trading volumes on pre-announcement window [t-3, t-1] are calculated by the specific type of option trading volume minus the preceding 5 trading days' average trading volume. The abnormal trading volume of buyer-initiated call option is denoted by BC, seller-initiated call option by SC, buyer-initiated put option by BP, seller-initiated put option by SP, near-the-money buyer-initiated call by BC(NTM), near-the-money seller-initiated call by SC(NTM), out-of-the-money buyer-initiated call by BC(OTM), out-of-the-money seller-initiated call by SC(OTM), near-the-money buyer-initiated put by BP(NTM), near-the-money seller-initiated put by SP(NTM), out-of-the-money buyer-initiated put by BP(OTM), out-of-the-money seller-initiated put by SP(OTM), and the control variable is the VIX level 1-day prior to the announcement time, denoted by VIX. The t-statistics are reported in the parentheses which are calculated by using Newey-West standard errors. Panel A reports the regression results of full sample period from 2004 to 2016, and Panel B reports the regression results of excluding financial crisis period of 2008 to 2009.

Panel A: The regression results of full sample period: 2004 to 2016

	Dependent variable: Ret_1h												
	Call volumes						Put volumes						
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
BC	0.046**						BP	0.010					
	(0.019)							(0.019)					
SC		0.021					SP		0.010				
		(0.014)							(0.021)				
BC(NTM)			0.048**				BP(NTM)			0.008			
			(0.019)							(0.021)			
SC(NTM)				0.022			SP(NTM)				0.009		
				(0.014)							(0.022)		
BC(OTM)					-1.203***		BP(OTM)					0.295**	
					(0.417)							(0.144)	
SC(OTM)						(0.701)	SP(OTM)						0.157
						(0.551)							(0.207)
VIX	0.022**	0.018**	0.021**	0.018**	(0.016)	0.003		0.019	0.019	0.018	0.018	0.029**	0.023
	(0.010)	(0.009)	(0.009)	(0.009)	(0.014)	(0.012)		(0.012)	(0.012)	(0.011)	(0.012)	(0.013)	(0.015)
Constant	(0.058)	(0.092)	(0.035)	(0.086)	0.292	(0.001)		(0.172)	(0.168)	(0.168)	(0.166)	(0.220)	(0.191)
	(0.155)	(0.176)	(0.151)	(0.176)	(0.221)	(0.192)		(0.173)	(0.172)	(0.171)	(0.170)	(0.190)	(0.189)
Observations	104	104	104	104	104	104		104	104	104	104	104	104
Adjusted R2	0.082	0.043	0.088	0.044	0.102	0.036		0.029	0.03	0.028	0.029	0.054	0.033

Panel B: The regression results of excluding financial crisis period of 2008 to 2009

	Dependent variable: Ret_1h												
	Call volumes							Put volumes					
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
BC	0.031**						BP	0.011					
	(0.014)							(0.017)					
SC		0.019					SP		0.008				
		(0.019)							(0.017)				
BC(NTM)			0.032**				BP(NTM)			0.010			
			(0.014)							(0.019)			
SC(NTM)				0.019			SP(NTM)				0.009		
				(0.019)							(0.017)		
BC(OTM)					(0.812)		BP(OTM)					0.198	
					(0.589)							(0.153)	
SC(OTM)						0.830	SP(OTM)						(0.053)
						(0.701)							(0.194)
VIX	(0.003)	(0.005)	(0.003)	(0.005)	(0.016)	0.001		(0.005)	(0.006)	(0.006)	(0.006)	0.002	(0.010)
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)		(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)
Constant	0.290	0.287	0.294	0.289	0.306	0.141		0.228	0.236	0.230	0.238	0.187	0.239
	(0.229)	(0.252)	(0.228)	(0.252)	(0.200)	(0.225		(0.230)	(0.234)	(0.229)	(0.235)	(0.233)	(0.208)
Observations	88	88	88	88	88	88		88	88	88	88	88	88
Adjusted R2	0.015	-0.0003	0.016	-0.001	-0.009	-0.01		-0.015	-0.016	-0.016	-0.016	-0.003	-0.018

Table VI: The Predictability of Directional Option Trading Volumes for Post FOMC Announcement VIX Level Change

This table reports the results of testing investors hedge post-FOMC announcement risk by trading options. The test is done by regressing 1-hour post-FOMC VIX level change, dvix1h, on various abnormal option trading volumes classified as buyer-initiated or seller-initiated by Lee and Ready (1991) algorithm. Abnormal option trading volumes on pre-announcement window [t-3, t-1] are calculated by the specific type of option trading volume minus the preceding 5 trading days' average trading volume. The abnormal trading volume of buyer-initiated call option is denoted by BC, seller-initiated call option by SC, buyer-initiated put option by BP, seller-initiated put option by SP, near-the-money buyer-initiated call by BC(NTM), near-the-money seller-initiated call by SC(NTM), out-of-the-money buyer-initiated call by BC(OTM), out-of-the-money seller-initiated call by SC(OTM), near-the-money buyer-initiated put by BP(NTM), near-the-money seller-initiated put by SP(NTM), out-of-the-money buyer-initiated put by BP(OTM), out-of-the-money seller-initiated put by SP(OTM), and the control variable is the VIX level 1-day prior to the announcement time, denoted by VIX. The t-statistics are reported in the parentheses which are calculated by using Newey-West standard errors. Panel A reports the regression results of full sample period from 2004 to 2016, and Panel B reports the regression results of excluding financial crisis period of 2008 to 2009.

Panel A: The regression results of full sample period: 2004 to 2016

	Dependent variable: dvix1h												
	Call volumes						Put volumes						
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
BC	-0.046***						BP	0.013					
	(0.017)							(0.022)					
SC		(0.021)					SP		0.018				
		(0.020)							(0.027)				
BC(NTM)			-0.048***				BP(NTM)			0.019			
			(0.017)							(0.024)			
SC(NTM)				(0.020)			SP(NTM)				0.020		
				(0.020)							(0.027)		
BC(OTM)					0.981*		BP(OTM)					-0.392*	
					(0.585)							(0.209)	
SC(OTM)						(0.700)	SP(OTM)						(0.102)
						(0.678)							(0.258)
VIX	-0.045***	-0.042***	-0.044***	-0.041***	(0.013)	-0.052**		-0.035***	-0.035***	-0.034***	-0.035***	-0.057***	-0.044***
	(0.013)	(0.013)	(0.012)	(0.013)	(0.024)	(0.021)		(0.012)	(0.011)	(0.011)	(0.011)	(0.016)	(0.016)
Constant	0.230	0.266	0.208	0.262	(0.036)	0.495		0.321	0.324	0.319	0.326*	0.412*	0.354*
	(0.223)	(0.222)	(0.222)	(0.223)	(0.339)	(0.317)		(0.197)	(0.198)	(0.196)	(0.198)	(0.233)	(0.215)
Observations	104	104	104	104	104	104		104	104	104	104	104	104
Adjusted R2	0.152	0.131	0.154	0.131	0.148	0.128		0.126	0.129	0.128	0.13	0.148	0.124

Panel B: The regression results of excluding financial crisis period of 2008 to 2009

	Dependent variable: dvix1h												
	Call volumes						Put volumes						
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
BC	-0.047**						BP	(0.009)					
	(0.022)							(0.022)					
SC		(0.030)					SP		0.003				
		(0.028)							(0.023)				
BC(NTM)			-0.048**				BP(NTM)			(0.004)			
			(0.022)							(0.023)			
SC(NTM)				(0.029)			SP(NTM)				0.004		
				(0.028)							(0.024)		
BC(OTM)					0.698		BP(OTM)					-0.464*	
					(1.263)							(0.241)	
SC(OTM)						(1.157)	SP(OTM)						(0.023)
						(1.058)							(0.329)
VIX	(0.029)	(0.026)	(0.029)	(0.026)	(0.015)	-0.034*		(0.025)	(0.021)	(0.023)	(0.021)	-0.045*	(0.023)
	(0.022)	(0.022)	(0.021)	(0.022)	(0.025)	(0.018)		(0.022)	(0.020)	(0.022)	(0.020)	(0.024)	(0.022)
Constant	(0.073)	(0.070)	(0.079)	(0.072)	(0.049)	0.141		0.019	0.017	0.016	0.018	0.118	0.019
	(0.316)	(0.330)	(0.314)	(0.329)	(0.345)	(0.294)		(0.332)	(0.325)	(0.328)	(0.326)	(0.363)	(0.317)
Observations	88	88	88	88	88	88		88	88	88	88	88	88
Adjusted R2	0.031	0.015	0.032	0.014	-0.003	0.002		-0.005	-0.006	-0.006	-0.006	0.035	-0.006

Table VII: Reverse Regressions of Abnormal Option Trading Volumes on Post-announcement Return and VIX Level Change

This table reports the regression results of joint test. The dependent variables are abnormal option trading volume of call option denoted by C, near-the-money call option by C(NTM), buyer-initiated call option by BC, near-the-money buyer-initiated call option by BC(NTM). There are two common independent variables in these regressions, the 1-hour post-FOMC announcement return, Ret_1h, and VIX level change, dvix1h.

Panel A: The regression results of full sample period: 2004 to 2016

	Dependent variable:					
	C	C(NTM)	BC	BC(NTM)	BC(OTM)	BP(OTM)
	(1)	(2)	(3)	(4)	(5)	(6)
Ret_1h	3.249**	3.256**	1.881**	1.885**	-0.004	0.219
	(1.291)	(1.273)	(0.838)	(0.827)	(0.079)	(0.143)
dvix1h	1.659	1.487	0.895	0.777	0.118	0.221
	(1.306)	(1.200)	(0.701)	(0.627)	(0.088)	(0.171)
Constant	-9.912***	-9.715***	-4.604***	-4.506***	-0.098**	-0.630***
	(1.217)	(1.189)	(0.574)	(0.559)	(0.039)	(0.125)
Observations	104	104	104	104	104	104
Adjusted R^2	0.015	0.018	0.026	0.032	0.144	0.033

Panel B: The regression results of excluding financial crisis period of 2008 to 2009

	Dependent variable:					
	C	C(NTM)	BC	BC(NTM)	BC(OTM)	BP(OTM)
	(1)	(2)	(3)	(4)	(5)	(6)
Ret_1h	2.302	2.209	1.211	1.181	0.031	0.159
	(1.791)	(1.769)	(1.290)	(1.280)	(0.023)	(0.122)
dvix1h	0.119	0.051	0.056	0.026	0.030	0.043
	(1.158)	(1.156)	(0.717)	(0.711)	(0.019)	(0.067)
Constant	-9.835***	-9.710***	-4.552***	-4.488***	-0.063***	-0.611***
	(1.333)	(1.314)	(0.617)	(0.608)	(0.020)	(0.130)
Observations	88	88	88	88	88	88
Adjusted R^2	0.013	0.013	0.014	0.015	0.005	-0.001

Note: *p<0.1; **p<0.05; ***p<0.01

Table VIII: Vuong's Test of Alternative Models

This table reports the p-values of Vuong's test of alternative models, which is a likelihood ratio test of distinguishable models. Two models are considered in our test, and one nests another. The null hypothesis of this test is the large model fits as well as the small model, and the alternative hypothesis is the large model fits better than the small model.

Panel A: The test results of full sample period: 2004 to 2016

	C	C(NTM)	BC	BC(NTM)	BC(OTM)	BP(OTM)
Ret_1h	0.327	0.329	0.326	0.338	0.334	0.327
dvix1h	0.084	0.06	0.089	0.067	0.929	0.371

Panel B: The results of excluding financial crisis period of 2008 to 2009

Ret_1h	0.9	0.904	0.891	0.891	0.216	0.657
dvix1h	0.341	0.355	0.417	0.425	0.294	0.334

Figure 1: The Level of VIX around FOMC Announcements

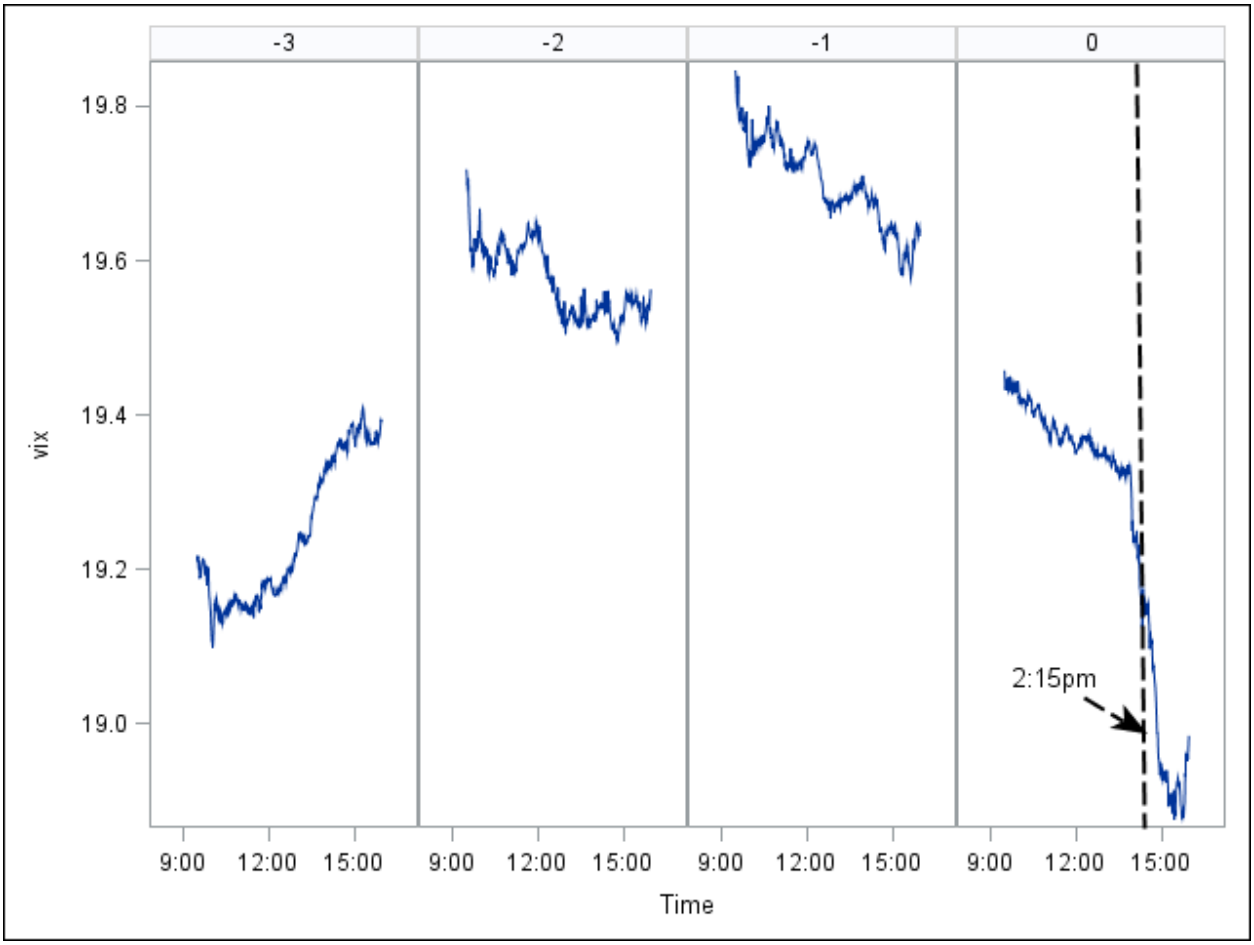

Figure 2: VIX daily time series: 2004 to 2016