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Why Do Options Prices Predict Stock Returns?*

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Abstract

We use a new approach to assess the information transmission between options and stock markets. We study whether the predictive power of option-implied volatilities (IVs) on stock returns lies in analyst-related and/or earnings-related news. We find that two proxies for options trading (IV skew and IV spread) predict analyst recommendation changes, analyst forecast revisions, and earnings surprises. Next, we show that the IV skew and IV spread predict stock returns, and that the degree of predictability more than doubles around analyst-related and earnings-related events. Additionally, we find that informed traders choose to use the options market particularly because of short-sale constraints on the underlying stock. We also find that the informed options trading increases with the options market liquidity.

JEL Classification: G12, G14, G17

Keywords: Informed traders, corporate events, implied volatility spread, implied volatility skew, short-sale constraint

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1. Introduction

Previous research argues that informed traders may take advantage of the high leverage in the options market to capitalize on their private information (Black (1975) and Back (1993)). In addition, options can be used to trade on negative information in case of short-sale constraints on the underlying stocks. One seminal study by Easley, O'Hara, and Srinivas (1998) proposes that options would be preferred by informed traders when the implicit leverage is high and the options market is liquid. Recently, a stream of empirical papers documents the informational leading role of the options market relative to the stock market.[1] Among others, Cremers and Weinbaum (2010) show that the deviation from put-call parity reflects information about future stock price changes, and Xing, Zhang, and Zhao (2010) find that the firm-level options volatility skew can predict future cross-sectional equity returns.

However, another stream of literature finds that options markets do not contribute to the equity price discovery process. Chan, Chung, and Fong (2002) show that stock net trading volume can predict future options quotes revisions but not vice versa. Their results suggest that informed investors only initiate their trades in the stock market. Muravyev, Pearson, and Broussard (2013) find that options quotes do not contain any non-public information about future underlying stock prices, and it is the stock price that leads the options quotes in the price discovery process.

These conflicting results show that it is hard to empirically determine where informed traders trade, potentially because a substantial part of the day-to-day movements in stock and options prices is not information driven. The key innovative aspect of our study is that we focus on periods where it is clear that substantial information is revealed to the market, thus providing a much cleaner test of the informational leading role of options markets. Specifically, we focus on the information in options markets around corporate events. We contribute to the literature by providing direct evidence that the options market leads the stock market by showing that a significant proportion of the options trading's predictability

[1] See, for example, Patell and Wolfson (1981); Amin and Lee (1997); Pan (2002); Chakravarty, Gulen, and Mayhew (2004); Cao, Chen, and Griffin (2005); Lakonishok, Lee, Pearson, and Poteshman (2007); Ni, Pan, and Poteshman (2008); Roll, Schwartz, and Subrahmanyam (2010); Chan, Li, Lin, and Lin (2012); Johnson and So (2012); and Chan, Ge, and Lin (2013).

on stock returns comes from informed options traders' private information about upcoming corporate events. We focus on three common and recurring corporate events: the analyst recommendation change, the analyst forecast revision, and the earnings announcement.

All three corporate news events have been shown to contain new information that moves the stock price, which would motivate informed investors to trade on their private information before the public announcements.[2] We thus examine whether options traders hold private information on the analyst-related and/or earnings-related corporate events by testing two hypotheses. First, can options trading activities of informed traders predict the direction and magnitude of analyst-related and/or earnings-related news? Second, can options trading activities of informed traders predict underlying stock returns, and to what extent does the predictability come from days with analyst-related and/or earnings-related corporate events?

We employ two proxies for options trading activities of informed traders based on previous studies, the implied volatility (IV) spread (Cremers and Weinbaum (2010)) and the IV skew (Xing, Zhang, and Zhao (2010)). The IV spread, which is the difference in IVs between matched pairs of call and put options with identical strike prices and maturities, has been demonstrated to be a positive predictor of equity returns.[3] On the other hand, the IV skew, defined as the difference between IVs of out-of-the-money (OTM) put options and at-the-money (ATM) call options, is shown to be negatively associated with future stock returns.[4] Intuitively, if informed traders anticipate a drop in the stock price, they are more likely to buy put options to capitalize on their private information, especially OTM puts. In a market that is not perfectly liquid, this will lead to a price increase in those put options, resulting in a decrease of the IV spread and an increase of the IV skew, and vice versa.

Using options pricing data and corporate news data from January 1996 to December 2010, our first key finding is that both the IV spread and the IV skew have economically large

[2] See, for example, Ball and Brown (1968); Foster, Olsen, and Shevlin (1984); Bernard and Thomas (1989); Stickel (1991); Womack (1996); Barber, Lehavy, McNichols, and Trueman (2001); and Gleason and Lee (2003).
[3] See, for example, Ofek, Richardson, and Whitelaw (2004); Bali and Hovakimian (2009); Atilgan (2010); Cremers and Weinbaum (2010); Chan, Li, Lin, and Lin (2012); and Chan, Ge, and Lin (2013).
[4] See, for example, Bates (1991); Bollen and Whaley (2004); Xing, Zhang, and Zhao (2010); Van Buskirk (2011); and Jin, Livnat, and Zhang (2012).

and statistically significant predictive power on future analyst-related and earnings-related events. Firms with a lower IV spread or higher IV skew in the pre-event week have more negative analyst recommendation changes, worse analyst forecast revisions, and lower standardized unexpected earnings (SUE).

Next, we perform regressions of stock returns on each informed options trading proxy. Consistent with previous studies, we document that the IV spread (IV skew) carries significantly positive (negative) information for future excess returns. Firms with lower IV spreads or higher IV skews experience lower stock returns in the following week. We then add interaction terms with dummy variables indicating days with analyst-related or earnings-related events, and calculate the proportion of the predictability of options trading on excess returns that is associated with the events. Our second key finding is that 11.21% (11.11%) of the predictability of the IV spread (IV skew) comes from the days with analyst recommendation changes, analyst forecast revisions, and earnings announcements. Since the event days constitute only 5.29% (6.12%) of the IV spread (IV skew) sample, the predictive power of the IV spread and skew doubles on news days, especially on analyst-related news, compared with no-news days. Still, a large part of the predictability is obtained on other days, which shows that options traders have information that goes beyond the corporate events that we study.

In addition, we investigate whether the short-sale constraint on the underlying stock is an important factor driving informed traders to the options market. Under tight short-sale constraints, it is expensive for investors to capitalize on their negative private information in the equity lending market. Then put options would be rational alternatives. Thus, we expect the options' predictability on stock returns being stronger for more negative scenarios, where the IV spreads (IV skews) are below (above) the median level indicating much higher demands for puts than calls. Using piece-wise linear regressions, we find that conditional on events' occurrences, only the below-median IV spread and above-median IV skew gain stronger predictability on excess returns. The results point directly toward the short-sale constraints argument.

We also examine the effects of options market liquidity on our results. Easley, O'Hara,

and Srinivas (1998) argue that liquidity plays an important role in whether the options market is more attractive to informed traders compared to the stock market. Consistent with their argument, we find that the proportion of the stock return predictability by options trading that is associated with the events decreases with the bid-ask spreads of options. Our findings indicate that more informed investors choose the options market to capitalize on their private information about the upcoming corporate news when the liquidity of options market is higher.

Furthermore, we study the IV spread and skew during the post-event weeks. If informed options traders believe that the market has not fully incorporated the event news into the stock prices, one would expect that the IV spread and skew remain at their pre-event level. On the contrary, if traders think the market has fully reacted to the event news, they would close their options positions, and the IV spread and skew would revert to their normal levels. Our result is consistent with the latter effect. It is also in line with the notion that informed traders are more likely to be contrarian traders as argued, for example, in Brennan and Cao (1996), Lakonishok and Lee (2001), Watanabe (2008), and Albuquerque and Miao (2010).

We conduct a series of robustness checks to validate our results. In a cross-sectional analysis, we sort firms into decile portfolios based on IV spread/skew and find that the four-factor abnormal returns during the week after portfolio formation are larger in magnitude in the sub-sample with occurrences of the three events than in the no-event sub-sample. It is consistent with our major finding that more informed investors participate in the options market around corporate events. We also employ alternative informed options trading measures in the main hypotheses tests: the options to stock trading volume (O/S) ratio which is recently shown to be a significant predictor of stocks returns (Roll, Schwartz, and Subrahmanyam (2010) and Johnson and So (2012)), the IV spread/skew over the previous month, and the changes of the IV spread/skew. Our results are robust to all these variations.

Our result indicates a strong lead-lag relation between options trading activities of informed traders and forthcoming analysts-related news. We thus dedicate the final part of the paper to exploring the role of analysts and option traders. We discuss three hypotheses that might explain this finding. First, analysts could inform options traders about their upcoming

recommendation change or earnings forecast revision ("analyst tipping"). Second, analysts and options traders may independently gather similar information but options traders can exploit this more quickly ("common information"). Third, options traders could leak their trading information to analysts leading to recommendation changes and forecast revisions by analysts ("reverse tipping"). Following the empirical setups in Irvine, Lipson, and Puckett (2006) and Christophe, Ferri, and Hsieh (2010), we perform explorative analyses to distinguish these explanations. Though it is difficult to strictly rule out any of these hypotheses, the results are most supportive of the analyst tipping hypothesis.

The remainder of the paper is organized as follows. Section 2 briefly reviews the related literature. Section 3 describes the data and provides summary statistics for the informed options trading measures and the event measures. Section 4 discusses empirical results for the two main hypotheses. Section 5 presents three additional tests for the role of the short-sale constraints, the effects of options market liquidity, and the options traders' post-event trading strategies. Section 6 shows various robustness checks. Section 7 discusses three hypotheses of how investors get informed of the analyst-related news. Section 8 concludes the paper.

2. Related literature and contribution

A large literature studies the information linkage between the options market and the stock market. In markets with frictions, options would be favored by informed investors due to the embedded leverage (Easley, O'Hara, and Srinivas (1998)), or when there are short-sale constraints on the underlying equity. One strand of research shows that options trading can predict underlying stock returns (e.g., Chakravarty, Gulen, and Mayhew (2004); Pan and Poteshman (2006); and Doran, Tarrant, and Peterson (2007)). Two frequently used informed trading measures constructed from the options market are the IV spread and the IV skew.

The IV spread measures the deviations from put-call parity. For American-style options, which allow early exercise, the deviation from put-call parity does not necessarily mean an arbitrage opportunity. In addition, in case of transaction costs, there is a range of call and put prices that precludes arbitrage even for European options. Then, in a market in which options

are not perfectly liquid, buy or sell pressure may lead to deviations from put-call parity that do not reflect an arbitrage opportunity but rather (informed) trading. In case of positive information, call buying pressure may push call IVs up, above put IVs. In case of negative information, the opposite may happen. If informed traders prefer the options market, the IV spread may then predict future stock returns. Bali and Hovakimian (2009) indeed find that the firm-level IV spread positively predicts stock returns. Cremers and Weinbaum (2010) show that the IV spread is positively related to future stock returns, and the predictability cannot be explained by short-sale constraints.

The IV skew is the difference between the IVs of OTM put options and ATM call options on the same security. The IV skew thus measures the left-shape of the IV function, and is found to contain negative predictive information for future stock returns. For example, Xing, Zhang, and Zhao (2010) sort stocks on their IV skew and find that stocks with high IV skews have lower subsequent returns. The intuition is again that informed traders buy OTM put options to express their negative information. Note that OTM options provide higher leverage than ATM or in-the-money (ITM) options.

We add to the existing literature on informed trading in equity and options in three ways. First, we are the first to study whether the IV spread and skew can predict the direction and magnitude of three important corporate events. This provides much more direct evidence of informed options trading since studies that focus on predicting returns can never rule out the possibility of time-varying risk premiums.

Second, we shed more light on the role of the IV spread and skew in predicting equity returns by analyzing whether this predictability is more prevalent around corporate events. Existing work has mainly focused on earnings announcements. Atilgan (2010) finds that stocks with a larger IV spread earn higher abnormal returns during a two-day earnings announcement window. Van Buskirk (2011) concludes that an increase in the IV skew suggests a higher probability of the firm experiencing crashes during short-window earnings announcement periods. Atilgan, Bali, and Demirtas (2011) find a negative correlation between the IV skew calculated from the S&P 500 index options and the expected stock

market return, and this relation becomes stronger around earnings announcements.[5] In our study, in addition to earnings announcements, we focus on analyst recommendation changes and forecast revisions. This is important since, in contrast to earnings announcements, the timing of these analyst-related events is not known ex-ante and hence it provides a more challenging test of whether informed traders use options to exploit information.

In sum, these first two contributions provide a comprehensive view on when and where informed agents trade. We focus on the role of options markets around reoccurring corporate events, because clearly these events constantly provide new information to financial markets. This allows us to test the informational leading role of options markets in a very direct way for a representative sample.[6]

A third (and minor) contribution is that we explore the relation between analysts and options traders in more detail. We perform explorative analyses to assess the role of the analyst tipping, common information, and reverse tipping, based on the methodologies of Irvine, Lipson, and Puckett (2006) and Christophe, Ferri, and Hsieh (2010).

3. Data description and summary statistics

Our sample period covers from January 1996 to December 2010. We use options data from OptionMetrics, a comprehensive database providing end-of-day bid and ask quotes, open interests, trading volumes and other relevant information for all options on US exchange listed equities. The events data of the analyst recommendation changes, the analyst forecast revisions, and the earnings announcements are extracted from the Institutional Brokers Estimate System (I/B/E/S). The stock trading data are from the Center for Research in Security Prices (CRSP). The general accounting data are provided by the Compustat.

The analyst-related and earnings-related events are quantified as follows: the analyst recommendation change is the total number of notches changed for a stock from all analysts,

[5] Note that the IV skew may also reflect a risk premium for jump risk. This would imply a positive relation between the IV skew and subsequent stock returns. Existing research does not find an important role for such an effect.

[6] Other existing studies link the options trading to specific and non-reoccurring corporate events. For example, Cao, Chen, and Griffin (2005) focus on announcement returns of M&A targets. Chan, Li, Lin, and Lin (2012) examine stock splits. Chan, Ge, and Lin (2013) explore the announcement return of M&A acquirers.

in which an analyst recommendation equals a number from 5 to 1, indicating strong buy, buy, hold, underperform, and sell, respectively; the analyst forecast revision is the change of the consensus analyst forecast defined as the mean of the earnings estimates from individual analysts; the earnings announcement is measured by the value of the standardized unexpected earnings (SUE), which is the announced earnings per share (EPS) less the corresponding consensus analyst forecast and scaled by the standard deviation of the quarterly earnings estimates.

[Table 1 to be inserted here]

Table 1 provides summary statistics on the three types of events. In our sample, the analyst forecast revision occurs most frequently. All three events are quite volatile across the sample. The SUE has a mean of -0.10% and a standard deviation of 1.75%; the average analyst recommendation change is -0.17, while its standard deviation is 1.61; and the analyst forecast revision has a mean of -0.93%, and its standard deviation is 6.04%.

The IV spread is calculated as the open-interest weighted average of the differences in IVs between matched pairs of call and put options on the same underlying with identical strike prices and expiration dates (Cremers and Weinbaum (2010)). The IV skew is defined to be the difference between IVs of the OTM put options and the ATM call options on the same stock (Xing, Zhang, and Zhao (2010)).[7] Detailed constructions of the two variables are in the appendix.

[Table 2 to be inserted here]

Table 2 reports time-series descriptive statistics for each informed options trading measure. For the full sample period of January 1996 to December 2010, we have in total 7,083,631 IV spreads calculated for 6,629 distinct firms, and 3,613,595 IV skews for 6,082 firms. Consistent with previous studies, the IV spread is on average negative, while the IV skew is on average positive. The average daily cross-sectional mean of the IV spread is -1.1%, indicating that put options are in general more expensive than the matched call options with

[7] A put option is OTM if its moneyness of the strike price to stock price ratio lies between 0.80 and 0.95. A call option is ATM if its moneyness is between 0.95 and 1.05.

the same strike prices and maturities. For the IV skew, the average daily cross-sectional mean is 5.5%, suggesting that OTM put options on average are more expensive than ATM call options on the same stocks. Both the IV spread and the IV skew exhibit substantial variations. The average daily cross-sectional standard deviation of the IV spread is 6.4% and 6.6% for the IV skew.

4. Main hypotheses and empirical results

In this section, we follow the empirical set up in Boehmer, Jones, and Zhang (2012) to examine whether options traders hold private information on the analyst-related and/or earnings-related corporate events such that their trading activities in the options market can predict future stock returns. First, we test whether options trading can predict the direction and magnitude of upcoming analyst-related or earnings-related corporate events? Second, does options trading have predictive power on future excess returns, and, to what extent does the predictability come from the analyst-related and/or earnings-related corporate events? The detailed empirical setup is outlined in each of the following subsections. All estimated standard errors are clustered by firm and calendar quarter to adjust for the cross-sectional and serial correlations in the pooled regression residuals (Petersen (2009)).[8]

4.1. Predictability of options trading on upcoming events

To test the first hypothesis, we perform pooled OLS regressions of the analyst-related or earnings-related events on each options trading measure:

$$event_{i,t} = \beta_0 + \beta_1 option_{i,t-5,t-1} + \beta_2 \ln size_{i,t-5,t-1} + \beta_3 bm_{i,y-1} + \beta_4 ret_{i,m-6,m-1} + \beta_5 \sigma_{i,m-1} + \beta_6 turnover_{i,t-5,t-1} + \beta_7 hskew_{i,m-1} + \beta_8 stockbasp_{i,t-5,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (1)$$

where $event_{i,t}$ indicates the measures capturing the analyst-related or earnings-related events described in Section 3. To alleviate the influence of extreme values, all event measures are winsorized at the 0.5% level in each tail.[9] The variable $option_{i,t-5,t-1}$ refers to the

[8] If we do not include year fixed effects, it is computationally feasible to cluster the standard error by firm and week. We find very similar results when clustering the estimated standard errors by firm and week.
[9] We obtain similar results when we winsorize the event measures at 1% level in each tail.

informed trading measures constructed from the options market five trading days before the event. It can take the value of $spread_{i,t-5,t-1}$ or $skew_{i,t-5,t-1}$ (the average IV spread and average IV skew over the pre-event week).

Other explanatory variables controlling for different firm characteristics include the average natural logarithm of the firm market capitalization during the previous week $\ln size_{i,t-5,t-1}$, the book-to-market ratio by the end of last calendar year $bm_{i,y-1}$, the cumulative stock return over the past six months $ret_{i,m-6,m-1}$, the stock return volatility in the previous month calculated using daily stock returns $\sigma_{i,m-1}$, the average turnover rate for the previous week calculated as the stock trading volume over the number of shares outstanding $turnover_{i,t-5,t-1}$, the historical skewness of the daily stock returns over the past month $hskew_{i,m-1}$, and the average stock bid-ask spread over the previous week defined as the closing ask less the closing bid and divided by the midpoint $stockbasp_{i,t-5,t-1}$. The year fixed effects are also included in the regressions.

We expect to find positive (negative) relations between the IV spread (IV skew) and the three corporate events of the analyst recommendation change, the analyst forecast revision, and the earnings surprise. If informed traders anticipate bad news to be announced, they are more likely to buy the put options to capitalize on their private information, especially the OTM puts, leading to a decrease in $spread_{i,t-5,t-1}$ and an increase in $skew_{i,t-5,t-1}$.

[Table 3 to be inserted here]

Table 3 reports the regression results for the IV spread. When the IV spread is the only independent variable, it significantly predicts all three events with the expected positive sign. With the inclusion of all control variables, the predictability of the IV spread remains statistically significant, with t-statistics of 8.22, 1.70, and 3.44 for the analyst recommendation change, the analyst forecast revision, and the earnings announcement respectively. The economic magnitude of the predictability is especially large for the earnings announcements. A one standard deviation increase in the IV spread is associated with an

increase in the SUE by 1.78 standard deviations.

[Table 4 to be inserted here]

Table 4 reports regression results for the IV skew. Without controlling firm characteristics, it has significant predictive power for all three events. Including all control variables does not take away the predictive power of the IV skew. All corporate events are still significantly predicted by the IV skew. Similar to the IV spread regressions, the economic magnitude of IV skew predictability is particularly large for future earnings announcements. A one standard deviation increase in the IV skew is accompanied with a decrease of 1.62 standard deviations in the SUE.

In sum, our findings suggest that the two proxies for informed options trading indeed possess economically large and statistically significant predictive power for future analyst-related and earnings-related corporate events.

4.2. Decomposition of options trading predictability on future stock returns

Our second hypothesis is to test whether and why options prices predict stock returns. The empirical estimations are conducted in three steps.

In the first step, excess returns are regressed on each options trading measure and the control variables:

$$exret_{i,t,t+4} = \beta_0 + \beta_1 option_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \qquad (2)$$

where $exret_{i,t,t+4}$ is the daily excess stock return, calculated as the stock return in excess of the market return, averaged over day t to day $t+4$. The $controls_{i,t-1}$ are the lagged control variables described in the previous subsection. If options market leads the stock market, we expect the IV spread to be positively correlated with future excess returns, and the IV skew to be negatively correlated with future excess returns.

In the second step, we add an interaction term between the options trading measure and a dummy variable indicating the occurrence of any of the three events into the regression (2):

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t})option_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (3)$$

where $eventday_{i,t}$ takes the value of 1 if one of the three events takes place for firm i on day t, and 0 otherwise. Therefore, when none of the events takes place, the predictability of options trading on future excess returns is measured as β_1. When any of the events occurs, the predictability becomes $\beta_1 + \beta_2$. So we decompose the predictability of options trading on stock returns into two parts: from the days with specified corporate events and from other days. The interacted coefficient β_2 indicates the predictability from the event day such that we can calculate the proportion of the predictability that is attributed to informed options traders' private information about the upcoming three types of events. Note that $\beta_1 + \beta_2$ captures the return effect one would obtain from the standard event study.

In the last step, we replace the $eventday_{i,t}$ in the previous step by three individual event dummy variables to test the hypothesis for each corporate event separately:

$$\begin{aligned} exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 revision_{i,t} + \beta_3 recommend_{i,t} + \beta_4 earnings_{i,t})option_{i,t-5,t-1} \\ + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \end{aligned} \quad (4)$$

where $recommend_{i,t}$ equals 1 if an analyst recommendation change takes place, and 0 otherwise; $revision_{i,t}$ equals 1 if an analyst forecast revision takes place, and 0 otherwise; and $earnings_{i,t}$ equals 1 if an earnings announcement takes place for firm i on day t, and 0 otherwise. By the same argument as in regression (3), the interacted coefficients of β_2, β_3, and β_4 help us to gauge the portion of the predictability that comes from informed options traders' private information for each corporate event.

[Table 5 to be inserted here]

Table 5 presents the regression results on the second hypothesis for the IV spread. The first two columns are for regressions in the first step. The IV spread is positively related to

future excess returns, with a t-statistic of 10.43 without controls and 10.39 with control variables. The coefficient estimates indicate that a one standard deviation increase in the IV spread would raise the average daily excess return in the following week by 3.12 basis points.

The third and fourth columns of Table 5 report regression results for the second step. When we only include the IV spread and its interaction term, the IV spread itself carries a significant coefficient of 0.47 (t-statistic = 10.40), and the interaction term has a significant coefficient of 0.56 (t-statistic = 3.05). In the fourth column, with inclusion of all the control variables, the coefficient estimate on the IV spread becomes 0.47 (t-statistic = 10.34), and the coefficient estimate on the interaction term is 0.59 (t-statistic = 3.21). Hence, the predictability of the IV spread over excess returns on event days is more than double of that on no-event days (1.06 vs. 0.47).

To further compute the exact percentages of the predictability that come from the events, we can follow the analysis in Boehmer, Jones, and Zhang (2012): since event days constitute 5.29% of the whole IV spread sample, the overall predictive power of the IV spread can be measured as: 0.47* (1 – 5.29%) + (0.47 + 0.59)* 5.29% = 0.50. So the fraction of the predictability that comes from the informed options traders' private information about the three events can be calculated as: (0.47 + 0.59)* 5.29% / 0.50 = 11.21%.

The last two columns of Table 5 report results for the last step. After including the three interaction terms between the IV spread and each corporate event dummy, and controlling for different firm characteristics and year fixed effects, the IV spread can still positively predict the excess return with a t-statistic of 10.35. The predictability gets significantly stronger on trading days when analyst-related news takes place. The interaction terms with both the analyst recommendation dummy and the analyst forecast revision dummy carry significant and positive coefficient estimates. Following similar calculations as in the previous paragraph, since days with analyst recommendation changes and analyst forecast revisions make 1.67% and 2.86% of the whole IV spread sample, approximately 5.47% and 6.20% of the predictability of the IV spread on excess returns can be attributed to informed options traders' private information about the regarded corporate event.

[Table 6 to be inserted here]

We then turn to the IV skew, and perform similar analysis. Table 6 presents the results. The first two columns report regressions in step one. The relation between the IV skew and future stock returns is significantly negative. When only including the IV skew, the coefficient estimate on it is -0.24, with a t-statistic of -4.44. With firm characteristics controlled, the coefficient estimate on the IV skew becomes -0.27, with a t-statistic of -5.79. A one standard deviation increase in the IV skew would decrease the average daily excess return in the following week by 1.76 basis points.

The third and fourth columns of Table 6 provide results for step two. Without controlling for firm characteristics, the coefficient estimate on the IV skew is -0.23 (t-statistic = -4.35), and the interacted coefficient is -0.24 (t-statistic = -2.13). After including all control variables, the IV skew has a statistically significant coefficient of -0.26, while the interaction term carries a significant coefficient of -0.23. The results imply that the predictability of the IV skew for stock returns on event days is nearly twice as large as that on no-event days (-0.49 vs. -0.26). If we take into account that the event days make 6.12% of the whole IV skew sample, the overall predictive power can be calculated as -0.26* (1 – 6.12%) + (-0.26 + (-0.23))* 6.12% = -0.27. The fraction of the predictability that is associated with informed options traders' private information about the events can be measured as (-0.26 + (- 0.23))* 6.12% / (-0.27) = 11.11%.

The last two columns in Table 6 present results distinguishing different types of corporate events. The interaction coefficient is significantly negative for both two analyst-related events. As presented in the last column, the IV skew has a significant coefficient of -0.25 (t-statistic = -5.47), and the interaction terms with the analyst recommendation change dummy and analyst forecast revision dummy carry significant coefficients of -0.63 (t-statistic = -4.21) and -0.24 (t-statistic = -1.67). Therefore, the predictability of the IV skew for stock return is more than three times larger on days with analyst recommendation changes than on other days (-0.88 vs. -0.25), and is almost twice as large as when analysts revise their earnings estimates (-0.49 vs. -0.25). By a similar calculation as in the previous step, because in the IV skew sample 1.92% and 3.44% of the

days are with analyst recommendation change and analyst forecast revision, about 6.41% and 6.51% of the return predictability by IV skew are associated with the analyst recommendation change and analyst forecast revision.

To sum up, we show that options trading activities have significant predictive power over future excess returns. We find that the predictability of options trading on excess returns is significantly related with investors' private information on analyst-related corporate events.[10] Compared with analyst-related events, the return predictability of options trading on earnings announcement days is not materially different compared with no-event days. One possible explanation is that earnings announcements are scheduled events, which may attract more attention of equity market participants right before the events. Some information possessed by the informed options traders may be incorporated into stock prices before the announcement. This, however, would not affect the conclusion we draw for our first hypothesis, as long as the consensus analyst forecast does not change before the earnings announcement.

5. Additional tests

5.1. Predictability of stock returns and short-sale constraints

Informed traders may use options to exploit negative private information when there are short-sales constraints on the underlying stocks. In this case, we would expect a larger portion of the options trading predictability on excess returns comes from cases of bad news. To test this argument, we run piece-wise regressions with the median of the options trading proxy as the kink point. The below-median IV spreads and above-median IV skews are more related with negative news, as they suggest much higher demands for put options than call options. For both IV spread and IV skew, two independent variables take the place of the original one in the regression model:

[10] For both the two hypotheses, we find qualitatively similar results when excluding analyst-related events within the three-day window of earnings announcement dates to adjust for the possible clustering of analyst reports around earnings dates.

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t})optionabove_{i,t-5,t-1} + (\beta_3 + \beta_4 eventday_{i,t})optionbelow_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (5)$$

where $optionabove_{i,t-5,t-1}$ takes value of average IV spread or IV skew over the previous week if it is above the median of the whole sample, and 0 otherwise. The $optionbelow_{i,t-5,t-1}$ takes the value of average IV spread or IV skew over the previous week if it is below the median of the whole sample, and 0 otherwise.

[Table 7 to be inserted here]

Table 7 is for the piece-wise regressions. If short-sale constraints are relevant driving forces, options trading regarding the negative news should be more predictive than the part regarding the positive news. We find that only for the below-median IV spread and above-median IV skew, their predictabilities on excess returns are strengthened on trading days with analyst recommendation changes, analyst forecast revisions, or earnings announcements. The below-median IV spread carries a positive coefficient of 0.50 (t-statistic = 8.10), and its interaction with the event dummy variable equals 0.94 (t-statistic = 3.41). The coefficient on the above-median IV skew is -0.25 (t-statistic = -5.39), and its interaction with the event dummy variable is -0.24 (t-statistic = -2.21). The results suggest that upon the occurrences of the three corporate events, for both IV spread and IV skew, only the negative news cases imply stronger predictive power over excess returns. The results point to the argument that when equity lending becomes expensive due to short-sale constraints, informed investors choose bearish options trading as an alternative to capitalize on their negative information.

5.2. Predictability of stock returns and options market liquidity

Easley, O'Hara, and Srinivas (1998) suggest that the options market would be preferred by informed traders compared to the stock market when the options liquidity is relatively higher. It is thus a natural extension to examine whether our results are stronger when the options market is more liquid. To test this conjecture, we use the options bid-ask spread, which is calculated as

the best ask price less the best bid price and scaled by the midpoint, as a proxy for the options market illiquidity.

We add interaction terms of the options bid-ask spread with the informed options trading measure and the event dummy variable into equation (3):

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 optbasp_{i,t-5,t-1})option_{i,t-5,t-1} + (\beta_3 + \beta_4 optbasp_{i,t-5,t-1})eventday_{i,t} * options_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (6)$$

where the $optbasp_{i,t-5,t-1}$ is the average bid-ask spread over the previous week. We expect β_4 to have the opposite sign of β_3, as we anticipate to see less options trading on private information about the corporate events when the options market is less liquid, that is, when options have higher bid-ask spreads.

[Table 8 to be inserted here]

Table 8 reports regression results for equation (6). The triple interaction between the event dummy, the options trading measure and the bid-ask spread equals -0.62 for the IV spread (t-statistic = -1.92) and 0.22 for the IV skew (t-statistic = 2.00); both suggest that the predictability of the options trading on future excess returns becomes less related to the three corporate events when the options market becomes less liquid.

Overall, consistent with Easley, O'Hara, and Srinivas (1998), we find that less informed investors choose the options market to capitalize on their private information about future analyst-related and/or earnings-related events when the options market liquidity decreases.

5.3. Options trading measures in the post-event period

Finally, we examine the trading strategies of options traders after the announcements of the corporate events. If options traders believe that the market has not fully incorporated the news into stock prices, they would continue to hold their options positions and the IV spread and IV skew would be expected to remain at their pre-event levels for some time. Alternatively, they would choose to liquidate their options, in which case one would expect the IV spread and IV skew to revert. In addition, if the events cause a structural change in

option risk premiums, one would also expect the IV spread and skew to remain at their pre-event levels. By studying the pattern of the IV spread and skew after the events, we therefore also check for the possibility that the pre-event option prices simply reflect a change in jump or volatility risk premiums.

The post-event period options trading is then investigated as follows:

$$option_{i,t+1,t+5} = \beta_0 + \beta_1 ret_{i,t} + \beta_2 option_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \qquad (7)$$

where the $option_{i,t+1,t+5}$ is the average of the daily informed options trading measures over day t+1 to day t+5. It can take the value of $spread_{i,t+1,t+5}$ and $skew_{i,t+1,t+5}$. The variable $ret_{i,t}$ is the stock return on the event day.

The coefficient on the event day return β_1 describes the post-event options trading following the event day stock price change. A negative (positive) β_1 for the IV spread (IV skew) suggests that informed traders reduce (or even reverse) their positions after the event announcements. In other words, they believe that the market has fully incorporated the news. If β_1 is zero, there is no change in the IV spread or skew, consistent with the view that informed traders maintain their options positions, as they believe that the news has not been fully incorporated in the stock price (or that option prices have changed structurally due to a change in risk premiums). Finally, a positive (negative) β_1 for the IV spread (IV skew) suggests that informed traders increase their options positions, perhaps because they believe that most of the news still has to be incorporated into the stock price.

[Table 9 to be inserted here]

Table 9 provides the regression results. For each corporate event, we find negative β_1 for the IV spread and positive β_1 for the IV skew, mostly with statistical significance, except for the IV skew in the earnings announcement case. The results indicate that options traders quickly reduce their options positions during the week after the release of corporate news,

and both options trading measures return to their normal levels after the stock price changes. These results also support the assumption that there are no structural changes in option risk premiums. In addition, our findings are consistent with existing literature on information-based trading, which show that informed investors are in aggregate contrarians in the short run.[11]

6. Robustness checks

6.1. Event-based long/short portfolio analysis

For robustness purposes, we look at the performance of the long/short portfolios formed on the two options trading proxies. We divide our sample into the event group and the no-event group based on occurrences of the analyst recommendation change, the analyst forecast change, or the earnings announcement. For each sub-sample, stocks are sorted into deciles every trading day based on the average IV spread or IV skew over the previous week. Abnormal returns with respect to the four Fama-French (1993) and Carhart (1997) factors during post-formation weeks are calculated for the long/short portfolios, which long stocks in the highest decile and short stocks in the lowest decile:

$$High_t - Low_t = \alpha + \beta_1(Rm_t - Rf_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 Momentum_t + \varepsilon_t, \quad (8)$$

[Table 10 to be inserted here]

Table 10 presents abnormal returns for the long/short portfolios in both sub-groups. In the value-weighted case, the IV spread hedge portfolio gains a positive daily abnormal return of 14.50 basis points (t-statistic = 5.18) in the post-formation week on event days, and 8.40 basis points (t-statistic = 7.09) on no-event days. The IV skew hedge portfolio earns a negative daily abnormal return of -6.30 basis points (t-statistic = -2.26) for the event group, and -5.20 basis points (t-statistic = -4.21) for the no-event group. Hence, stocks with high IV

[11] See, for example, Brennan and Cao (1996); Lakonishok and Lee (2001); Watanabe (2008); and Albuquerque and Miao (2010).

spreads (low IV skews) outperform stocks with low IV spreads (high IV skews), and more so around event days.[12]

6.2. The O/S ratio

The O/S ratio has newly been demonstrated to contain information about future stock prices. Roll, Schwartz, and Subrahmanyam (2010) show that the O/S ratio increases significantly around earnings announcements, and firms with higher O/S ratios earn more absolute cumulative abnormal returns during post-announcement periods. Johnson and So (2012) find that the O/S ratio is negatively correlated with future excess returns and firms' earnings news, implying private information from options traders.

To gain more supportive evidence for our study, we investigate whether the predictability of O/S ratio on equity returns is also associated with the analyst-related and/or earnings-related corporate events. Following Roll, Schwartz, and Subrahmanyam (2010), we construct the O/S ratio as the total share volume of all options traded divided by the stock share volume:

$$O/S_{i,t} = (\sum 100 * option\ volume_{i,t}) / stock\ volume_{i,t}, \tag{9}$$

The options trading volume is multiplied by 100, since each option contract entitles the owner to 100 shares of the underlying equity.

We follow Roll, Schwartz, and Subrahmanyam (2010) and Johnson and So (2012) to put the absolute and actual values of excess returns on the left-hand side of the empirical tests, respectively:

$$abs(exret)_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t}) * O/S_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \tag{10}$$

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t}) * O/S_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \tag{11}$$

[12] We get qualitatively similar results using equal weighting.

where $abs(exret)_{i,t,t+4}$ is the average absolute excess returns over day t to day $t+4$, and $O/S_{i,t-5,t-1}$ is the ratio of the average options trading volume to the average stock trading volume over day $t-5$ to day $t-1$.

[Table 11 to be inserted here]

As shown in the first column of Table 11, the O/S ratio significantly and positively predict absolute excess returns, suggesting that there are more options trading activities relative to stock trading during weeks prior to the equity price change. In the second column, the predictability of O/S over absolute excess returns on event days is close to four times the magnitude of the predictability on other days (0.52 vs. 2.02), implying much more informed trading in the options market before public announcements of the corporate news. Without taking absolute value of the stock returns, we find that O/S is a significant negative predictor for excess returns, consistent with Johnson and So (2012). The predictability of O/S on the excess return almost doubles when the analyst-related and/or earnings-related events take place (-0.15 vs. -0.08).

6.3. Variations on construction of IV skew and IV spread

In this subsection, we perform variations on the two informed options trading measures as robustness checks. One variation is on the period over which we look at the IV spread and IV skew. In the benchmark analysis, we use the average over the previous week. Now, we use the average over the previous month:

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t}) * option_{i,t-22,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (12)$$

Another variation is to use the changes in the weekly average IV spread and IV skew instead of the levels of the variables, and we perform similar regressions as before:

$$optionchange_{i,t} = option_{i,t-5,t-1} - option_{i,t-10,t-6}, \quad (13)$$

$$exret_{i,t,t+4} = \beta_0 + (\beta_1 + \beta_2 eventday_{i,t}) optionchange_{i,t} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \quad (14)$$

[Table 12 to be inserted here]

As presented in Table 12, in regression (12), with average informed options trading proxies over the previous month, the coefficient on the IV spread is 0.33 (t-statistic = 4.35), and its interaction term with the event dummy variable is 0.81 (t-statistic = 3.44). The IV skew coefficient is -0.17 (t-statistic = -2.75), and the interacted coefficient is -0.26 (t-statistic = -2.37). The results are consistent with the findings in the main hypotheses testing, showing that the return predictability of informed options trading gets considerably strengthened on corporate news announcement days.

For regression (14), using changes in the informed options trading measures, the IV spread change carries a coefficient of 0.35, and its interaction with the event dummy variable is 0.26. The coefficient on the IV skew change is -0.26, and its event dummy interaction is -0.15. The changes of both informed options trading proxies become more predictive about excess returns on trading days with analyst-related and/or earnings-related corporate events.

6.4. Other proxies

We also construct various other informed options trading proxies. Specifically, we consider the "left IV spread," the "right IV spread," the "left IV skew," and the "right IV skew." The left IV spread is the open-interest weighted average of the IV differences between matched pairs of OTM put options and ITM call options with the same strike price and expiration date. The right IV spread is the open-interest weighted average of the IV differences between matched OTM call options and ITM put options.[13] The left IV skew is the IV difference between OTM put options and ATM put options, and the right IV skew is the IV difference between OTM call options and ATM call options.[14] We should anticipate the left IV spread and the left IV skew to predict negative corporate events and excess returns, and the right IV spread and the right IV skew to predict positive events and returns. In results not tabulated for brevity, we get expected results for these alternative measures, except for the right IV skew,

[13] A call option is ITM if its moneyness is between 0.8 and 0.95 and OTM if its moneyness is between 1.05 and 1.2. A put option is ITM if the moneyness is between 1.05 and 1.2.

[14] A put option is ATM if its moneyness is between 0.95 and 1.05. For each stock each day, we choose one ATM put/call option with moneyness closest to 1, one OTM put option with moneyness closest to 0.95, and one OTM call option with moneyness closest to 1.05.

which has little predictive power. It also suggests that using negative information is more important in the options market, which is consistent with our results in the piece-wise regressions.

6.5. Lending fees

A final robustness check concerns lending fees associated with shorting stocks. If informed investors want to short stocks to capitalize on their private negative information, the excess shorting demand may increase lending fees, which in turn affects price of puts (through put-call parity) and the IV skew and spread. Therefore, the predictability of IV spread and skew on forthcoming negative corporate news is also consistent to the notion that informed traders reveal their private negative information through the lending market instead of the options market.

To address the concern, we re-do our main analysis and control for the lending fees. We use daily lending market data from Data Explorers and find that our main results still hold after controlling for the lending fees. Results for this analysis are not reported for brevity and available upon request.

6.6. Inaccuracy of analyst report time stamp

Hoechle, Schaub, and Schmid (2013) find that the announcement date in I/B/E/S is on average delayed by about 0.64 trading days in the period spanning from 1994 to 2001.[15] Note that we average the IV spread and skew over the 5 trading days before the event. Also, we use a 5-day window to calculate stock returns after the event. Hence we do not expect this delay to be a major issue for our analysis. Still, to alleviate any concern that the predictability we documented is driven by the delayed time stamp of I/B/E/S, we conduct a sub-period analysis using data from 2002 to 2010. We find qualitatively similar results for our first and second hypotheses. Results are not reported for brevity and available upon request as well.

[15] Bradley, Clarke, Lee, and Ornthanalai (2013) also find that the average time stamp delay for recommendations is around 2.4 hours for NYSE stocks between 2002 and 2007. The majority occur before the market opens. Therefore, this intraday delay would not materially affect our analysis.

7. Discussion on the lead-lag relation between options trading and analyst-related news

In the previous sections, we showed that informed options traders have private information on analyst-related and/or earnings-related corporate news. Furthermore, the options trading predictability on the stock return is particularly strong on days prior to analyst recommendation changes and analyst forecast revisions. For example, the last column of Table 6 shows that the coefficients before IV skew are -0.90 on days with analyst recommendation changes and -0.25 on the no-event days. In this section, we provide explorative analysis on the relative merit of three possible explanations regarding the lead-lag relation between options trading and analyst-related news. Note that the following three hypotheses may not be mutually exclusive and can exist at the same time.

7.1. Three hypotheses

The first hypothesis is analyst tipping: Informed traders acquire the information from the analysts before public announcements of the recommendation changes or forecast revisions. They capitalize on the tips by trading in the options market prior to the events such that the excess demand pressure in the options market can predict analyst-related news. The tipping hypothesis is in line with the studies by Irvine, Lipson, and Puckett (2006) and Christophe, Ferri, and Hsieh (2010). The former shows that some institutional investors receive tips from sell-side analysts with regard to forthcoming analysts' reports, and the latter suggests that some traders are tipped by analysts about upcoming downgrades and reveal the tips through short sales.

The second hypothesis, common information, is that informed traders and sell-side analysts analyze the same available materials at hand and draw similar conclusions at the same time. However, informed investors can trade in the options market immediately, while the sell-side analysts need to spend time on writing the reports and going through the internal compliance. Our conversations with analysts suggest that the compliance process might take a few days, which are consistent with the five-day window of our predictability.

The third hypothesis is the reverse tipping: Informed traders tip their recent trading activities to the sell-side analysts. In reality, sell-side analysts are usually more junior than buy-side analysts and asset managers, who are arguably more well-informed.[16] Cen, Dasgupta, and Ragunathan (2012) show that sell-side analysts benefit from buy-side analysts' information production abilities. If some sell-side analysts ask for views or recent trading activities of informed options traders (e.g., hedge fund managers) to help them write the report, it can also lead to the lead-lag relation between options trading and the analyst-related news.

7.2. Analyst tipping vs. common information

Following Christophe, Ferri, and Hsieh (2010), in this subsection, we try to differentiate the first two possible explanations, analyst tipping and common information, by examining the relation between the IV spread/skew and most recent SUE prior to the analyst-related events. Under the common information hypothesis, if both options investors and analysts make predictions of the stock performance using the same fundamental information like the earnings performance, we expect to find a more positive (negative) preceding SUE for stocks with higher IV spread (skew) before the analyst-related news announcement. On the contrary, we should not observe this pattern according to the analyst tipping hypothesis.

We sort our sample into quintiles based on the average IV spread and skew during the pre-event week, and check the pattern of the most recent SUEs before the analyst recommendation changes or forecast revisions.

[Table 13 to be inserted here]

As shown in Table 13, the sorting results are inconsistent with the common information hypothesis. In the case of IV spread, the mean SUEs for the high-minus-low quintiles are -0.047% (t-statistic = -1.81) and -0.086% (t-statistic = -4.29) for the analyst recommendation change and analyst forecast revision, respectively. As for IV skew, the mean SUE of the high-minus-low quintile is 0.070% for the analyst recommendation change, and is 0.077% for

[16] The career path for industry research usually starts from the sell-side analyst to the buy-side analyst, and then to the asset manager.

the analyst forecast revision. The findings are thus more in line with the analyst tipping hypothesis.

7.3. Analyst tipping vs. reverse tipping

The previous result is less consistent with the common information story. However, the result could be both consistent with the tipping and reverse tipping hypotheses. Based on Irvine, Lipson, and Puckett (2006), we therefore examine the predictability of options trading on analysts' initial recommendations (i.e., analysts' very first recommendations on stocks) to distinguish between the two hypotheses. Irvine, Lipson, and Puckett (2006) argue that it is unlikely that analysts initiate coverage on a stock in response to a tip received from informed traders. First of all, the initiation of coverage is costly and time consuming, and second, the frequency of initiation seems to be too low. During our sample period through 1996 to 2010, one analyst on average issue 0.81 initiations each year. If sell-side analysts were responding to tips from asset managers who trade options, the number should be larger. Thus, if the reverse tipping hypothesis dominates, we may not find any predictability of options trading on analysts' initial recommendations. On the contrary, if the analyst tipping phenomenon prevails, we can still find some predictive power of options trading over analyst initiations. We run the following pooled regression similar to our main analysis:

$$initial\_rec_{i,j,t} = \beta_0 + \beta_1 option_{i,t-5,t-1} + \delta controls_{i,t-1} + \gamma Year\ fixed\ effects + \varepsilon_{i,t}, \qquad (15)$$

where $initial\_rec_{i,j,t}$ is the initial recommendation issued by analyst j for stock i on day t.[17]

[Table 14 to be inserted here]

Table 14 presents the estimation results. Both the IV spread and the IV skew are significantly correlated with the analyst initial recommendation. The IV spread positively predicts analysts' initial recommendations with a t-statistic of 4.05, while the IV skew

[17] We obtain the analyst initiation sample following Irvine, Lipson, and Puckett (2006). We find the first recommendation from an analyst on a stock in the I/B/E/S since December 14, 1992. To address the concern that an initiation record could be just a new entry of a brokerage firm into the database, observations are excluded from the sample if the brokerage firm appears in the I/B/E/S for less than six months before the initiation.

negatively predicts analyst initiations with a t-statistic of -5.09. The results seem to be more consistent with the analyst tipping hypothesis.

We admit that our analyses to distinguish the three hypotheses are not perfect. For instance, the common information shared by options investors and analysts may not be confined in the earnings. It is also difficult to completely rule out any of the three hypotheses. Still, our results provide suggestive evidence that the analyst tipping is the most relevant channel through which options traders get informed about the analyst-related corporate news.

8. Conclusion

Existing work has not reached a conclusion whether the options market really leads the stock market in information revealing. One line of research demonstrate that options trading can predict stock returns either due to information or jump risk (Pan (2002) and Bali and Hovakimian (2009)), while the opposite strand of studies show that the options market barely plays a role in the price discovery process (Chan, Chung, and Fong (2002) and Muravyev, Pearson, and Broussard (2013)). Our paper contributes to the literature by providing conclusive evidence that the options trading can predict excess stock returns because informed investors choose the options market to trade on their private information about upcoming analyst-related and earnings-related corporate events, namely the analyst recommendation change, the analyst forecast revision, and the earnings announcement. Using both the IV spread and the IV skew as informed options trading measures, we document economically large and statistically significant predictive power of informed options trading on all three informational corporate events. More importantly, we decompose the predictability of options trading on stock returns. We find that 11.21% of the predictive power of the IV spread and 11.11% of the predictive power of the IV skew come from informed options traders' private information associated with the upcoming analyst-related and/or earnings-related corporate news. In this way, we find the information sources which lie beneath the documented predictive patterns. The results are more pronounced when the options market is more liquid. We also show that the short-sale constraint plays an important role when informed investors choose the options market to capitalize on their private

information. Our results on analyst-related events are most consistent with the analyst tipping hypothesis that some options investors receive tips from analysts about future recommendations and earnings forecasts.

Appendix: Measures of informed options trading

For the options data, we employ the following filters following Xing, Zhang, and Zhao (2010) to reduce the effects of illiquid options and outliers: i) the volume of the underlying stock is positive; ii) the price of the underlying stock is above \$5; iii) the implied volatility of the option is between 0.03 and 2; iv) the mean of the best bid and best ask prices of the options is above \$0.125; v) the open interest of the options is positive; vi) the trading volume of the options is not missing; and vii) the time to maturity of the options is within 10 to 60 days.

A.1. IV spread

The IV spread is calculated after Cremers and Weinbaum (2010). For stock i on day t, which has n pairs of matched call and put options with identical strike prices and expiration dates, the IV spread is calculated to be the open-interest weighted average of the differences in IVs between the matched call and put options:

$$spread_{i,t} = \sum_{j=1}^{n_{i,t}} w_{j,t}^{i} (IV_{j,t}^{i,call} - IV_{j,t}^{i,put}), \tag{16}$$

We find qualitatively similar results using the options trading volume as the weighting.

A.2. IV skew

We construct the measure of the IV skew after Xing, Zhang, and Zhao (2010) as the difference between the IVs of the OTM put options and ATM call options:

$$skew_{i,t} = IV_{i,t}^{OTMP} - IV_{i,t}^{ATMC}, \tag{17}$$

In case of more than one record of OTM put or ATM call options for one stock on one day, we choose the put options with the moneyness closest to 0.95 and the call options with the moneyness closest to 1.

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Table 1: Analyst-related and earnings-related events

Table 1 reports descriptive statistics on the analyst-related and earnings-related events. Data are obtained from the I/B/E/S. The full sample period is January 1996 to December 2010. Recommendation change is the total number of notches changed. An analyst recommendation equals a number from 5 to 1, indicating strong buy, buy, hold, underperform, and sell, respectively. Forecast revision is the new analyst consensus less the old one. Earnings announcement is measured by the SUE, which is the announced quarterly EPS less the corresponding consensus analyst forecast and scaled by the standard deviation of the quarterly earnings estimates. Firm is the number of firms included. Day is the number of event days. Std is the standard deviation across observations. N is the number of observations.

Event	Firm	Day	25%	Median	75%	Mean	Std	N
Recommendation change	11,356	4,747	-1	-1	1	-0.17	1.61	189,026
Forecast revision	10,425	4,805	-0.71%	-0.11%	0.20%	-0.93%	6.04%	307,019
Earnings announcement	11,966	4,116	-0.06%	0.04%	0.20%	-0.10%	1.75%	184,315

Table 2: Time-series descriptive statistics for informed options trading measures

This table provides descriptive statistics for the IV spread and the IV skew by calendar year. Data are obtained from the OptionMetrics. The full sample period is January 1996 to December 2010. IV spread is the difference in IVs between matched pairs of call and put options on the same security with identical strike prices and maturities. IV skew is the difference between IVs of the OTM put option and the ATM call option on the same stock. Cross-sectional statistics for each day are calculated first, and then we take the average of the daily time series. Firm is the number of firms included. Std is the standard deviation across observations.

Year	Firm	25%	Median	75%	Mean	Std
Panel A: IV spread						
1996	1,917	-0.046	-0.011	0.024	-0.011	0.083
1997	2,364	-0.046	-0.012	0.022	-0.012	0.076
1998	2,671	-0.047	-0.012	0.022	-0.013	0.080
1999	2,812	-0.044	-0.011	0.022	-0.012	0.079
2000	2,728	-0.049	-0.013	0.022	-0.014	0.093
2001	2,371	-0.039	-0.012	0.011	-0.016	0.067
2002	2,330	-0.028	-0.008	0.009	-0.010	0.050
2003	2,245	-0.022	-0.005	0.009	-0.007	0.042
2004	2,442	-0.019	-0.005	0.007	-0.007	0.036
2005	2,573	-0.019	-0.005	0.006	-0.009	0.048
2006	2,837	-0.018	-0.005	0.007	-0.009	0.042
2007	3,128	-0.022	-0.006	0.008	-0.010	0.047
2008	3,125	-0.042	-0.011	0.015	-0.018	0.081
2009	3,033	-0.035	-0.010	0.012	-0.014	0.068
2010	3,233	-0.028	-0.006	0.012	-0.010	0.064
All	6,629	-0.034	-0.009	0.014	-0.011	0.064
Panel B: IV skew						
1996	1,611	0.005	0.036	0.076	0.045	0.076
1997	2,055	0.005	0.035	0.077	0.047	0.075
1998	2,335	0.008	0.039	0.082	0.051	0.079
1999	2,425	0.003	0.030	0.066	0.041	0.072
2000	2,330	0.001	0.029	0.066	0.039	0.083
2001	2,032	0.022	0.048	0.082	0.058	0.065
2002	1,955	0.040	0.064	0.097	0.073	0.058
2003	1,838	0.037	0.056	0.083	0.066	0.053
2004	2,041	0.027	0.044	0.066	0.052	0.048
2005	2,115	0.025	0.042	0.067	0.056	0.066
2006	2,369	0.023	0.039	0.063	0.052	0.061
2007	2,692	0.023	0.041	0.067	0.052	0.059
2008	2,638	0.030	0.057	0.093	0.068	0.076
2009	2,461	0.035	0.058	0.088	0.065	0.060
2010	2,728	0.029	0.049	0.075	0.058	0.063
All	6,082	0.021	0.045	0.077	0.055	0.066

Table 3: Predicting corporate events using the IV spread

This table presents pooled OLS regression results from regressing the event measures on the IV spread, with estimated standard errors clustered by firm and calendar quarter. Recommendation change is the total number of notches changed. An analyst recommendation equals a number from 5 to 1, indicating strong buy, buy, hold, underperform, and sell, respectively. Forecast revision is the new analyst consensus less the old one. Earnings announcement is measured by the SUE, which is the announced quarterly EPS less the corresponding consensus analyst forecast and scaled by the standard deviation of the quarterly earnings estimates, expressed in percentages. IV spread is the average IV spread over the pre-event week. Size is the natural logarithm of firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Measures of events					
	Recommendation change		Forecast revision		Earnings announcement	
Intercept	-0.100***	-0.458**	-0.005***	-0.012***	0.023**	-0.012
	(-3.03)	(-2.54)	(-7.15)	(-3.24)	(2.03)	(-0.11)
IV spread	1.064***	1.181***	0.015***	0.009*	0.608***	0.486***
	(7.61)	(8.22)	(2.70)	(1.70)	(3.18)	(3.44)
Size		0.025***		0.001***		0.008*
		(4.28)		(3.58)		(1.81)
B/M		0.002***		-0.001**		-0.008
		(3.04)		(-2.30)		(-1.12)
Momentum		0.010		0.008***		0.144***
		(0.30)		(7.42)		(5.71)
Volatility		-2.142***		-0.098***		-4.022***
		(-3.15)		(-7.03)		(-5.01)
Turnover		-2.004***		-0.096***		-0.511
		(-4.00)		(-2.58)		(-0.84)
Hskew		0.215***		0.003***		0.074***
		(25.57)		(12.34)		(10.33)
Stock bid-ask spread		-0.013		-0.001***		-0.024***
		(-1.49)		(-3.69)		(5.71)
Year FE	No	Yes	No	Yes	No	Yes
N	121,107	108,975	204,193	185,526	83,302	74,944
Adj R2 (%)	0.09	3.76	0.03	4.29	0.08	1.98

Table 4: Predicting corporate events using the IV skew

This table reports pooled OLS regressions of the three event measures on the IV skew. Estimated standard errors are clustered by firm and calendar quarter. Recommendation change is the total number of notches changed. An analyst recommendation equals a number from 5 to 1, indicating strong buy, buy, hold, underperform, and sell, respectively. Forecast revision is the new analyst consensus less the old one. Earnings announcement is measured by the SUE, which is the announced quarterly EPS less the corresponding consensus analyst forecast and scaled by the standard deviation of the quarterly earnings estimates, expressed in percentages. IV skew is the average IV skew over the pre-event week. Size is the natural logarithm of firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Measures of events					
	Recommendation change		Forecast revision		Earnings announcement	
Intercept	-0.039	-0.438**	-0.002***	-0.003	0.083***	0.466***
	(-1.28)	(-2.25)	(-4.72)	(-0.58)	(11.61)	(3.91)
IV skew	-1.196***	-1.007***	-0.027***	-0.015***	-0.548***	-0.429***
	(-5.94)	(-6.80)	(-4.99)	(-4.52)	(-3.30)	(-3.68)
Size		0.025***		0.0003		-0.012***
		(4.22)		(1.37)		(-2.75)
B/M		0.001		-0.001**		-0.024
		(0.96)		(-2.02)		(-1.49)
Momentum		-0.018		0.008***		0.097***
		(-0.51)		(7.07)		(4.18)
Volatility		-1.517*		-0.121***		-2.790***
		(-1.89)		(-8.00)		(-3.55)
Turnover		-1.789***		-0.065***		-0.588
		(-3.45)		(-2.64)		(-0.97)
Hskew		0.195***		0.002***		0.057***
		(19.65)		(10.35)		(9.82)
Stock bid-ask spread		-0.014		-0.001**		-0.003
		(-1.59)		(-2.27)		(-0.37)
Year FE	No	Yes	No	Yes	No	Yes
N	86,528	78,500	152,673	139,916	54,941	49,780
Adj R2 (%)	0.23	3.04	0.21	3.73	0.21	1.74

Table 5: When does the IV spread predict stock returns?

The table below shows pooled daily regressions of excess returns on the IV spread and its interaction terms with the event dummy variables. Estimated standard errors are clustered by firm and calendar quarter. Excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. IV spread is the average IV spread over the previous week. Eventday is a dummy variable that equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Recommend, Forecast, and Earnings are dummy variables indicating the occurrence for each event respectively. Size is the natural logarithm of the firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return for the previous six months. Volatility is the daily equity return volatility in the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Excess return					
Intercept	0.015	0.037**	0.015	0.037**	0.015	0.037**
	(1.40)	(2.09)	(1.40)	(2.09)	(1.40)	(2.08)
IV spread	0.486***	0.488***	0.466***	0.466***	0.464***	0.463***
	(10.43)	(10.39)	(10.40)	(10.34)	(10.40)	(10.35)
Eventday*IV spread			0.558***	0.590***		
			(3.05)	(3.21)		
Recommend*IV spread					1.004***	1.114***
					(5.33)	(6.05)
Forecast*IV spread					0.530**	0.576***
					(2.46)	(2.86)
Earnings*IV spread					0.184	0.160
					(0.74)	(0.61)
Size		-0.001		-0.001		-0.001
		(-0.17)		(-0.15)		(-0.14)
B/M		0.0003**		0.0001**		0.0001**
		(2.29)		(2.27)		(2.27)
Momentum		-0.007		-0.007		-0.007
		(-0.36)		(-0.36)		(-0.37)
Volatility		0.120		0.125		0.127
		(0.16)		(0.17)		(0.17)
Turnover		-0.044		-0.043		-0.041
		(-0.38)		(-0.36)		(-0.35)
Hskew		0.010***		0.010***		0.010***
		(3.52)		(3.52)		(3.52)
Stock bid-ask spread		-0.007		-0.007		-0.007
		(-0.62)		(-0.62)		(-0.62)
Year FE	No	Yes	No	Yes	No	Yes
N	7,382,894	6,284,062	7,382,894	6,284,062	7,382,894	6,284,062
Adj R2 (%)	0.03	0.11	0.04	0.12	0.04	0.11

Table 6: When does the IV skew predict stock returns?

This table provides pooled daily regressions of excess stock returns on the IV skew and its interactions with the event dummy variables. Estimated standard errors are clustered by firm and calendar quarter. Excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. IV skew is the average IV skew over the previous week. Eventday is a dummy variable which equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Recommend, Forecast, and Earnings are dummy variables indicating the occurrence for each event, respectively. Size is the natural logarithm of the firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return for the previous six months. Volatility is the daily equity return volatility in the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Excess return					
Intercept	0.020**	0.059***	0.020**	0.059***	0.020**	0.059***
	(1.96)	(3.38)	(1.98)	(3.37)	(1.98)	(3.35)
IV skew	-0.239***	-0.267***	-0.229***	-0.256***	-0.226***	-0.253***
	(-4.44)	(-5.79)	(-4.35)	(-5.57)	(-4.29)	(-5.47)
Eventday*IV skew			-0.238**	-0.232**		
			(-2.13)	(-2.23)		
Recommend*IV skew					-0.657***	-0.632***
					(-4.28)	(-4.21)
Forecast*IV skew					-0.221	-0.241*
					(-1.37)	(-1.67)
Earnings*IV skew					0.071	0.059
					(0.48)	(0.38)
Size		-0.002		-0.002		-0.002
		(-0.54)		(-0.49)		(-0.46)
B/M		0.0001		0.0001		0.0001
		(0.77)		(0.74)		(0.74)
Momentum		-0.009		-0.009		-0.009
		(-0.44)		(-0.45)		(-0.45)
Volatility		-0.457		-0.448		-0.440
		(-0.59)		(-0.58)		(-0.57)
Turnover		-0.140		-0.137		-0.132
		(-1.20)		(-1.17)		(-1.14)
Hskew		0.013***		0.013***		0.013***
		(3.96)		(3.95)		(3.94)
Stock bid-ask spread		-0.010		-0.010		-0.010
		(-0.71)		(-0.71)		(-0.71)
Year FE	No	Yes	No	Yes	No	Yes
N	4,627,618	3,939,824	4,627,618	3,939,824	4,627,618	3,939,824
Adj R2 (%)	0.02	0.10	0.02	0.10	0.02	0.10

Table 7: Predictability of stock returns and short-sale constraints

As in Tables 5 and 6, this table reports results of pooled daily regressions of excess stock returns on the options trading measures and their interactions with the event dummy variables. The IV skew and spread are split up into two variables, separately capturing the impact of the IV spread/skew above and below the median value. Regressions are conducted for the IV spread and IV skew separately. Standard errors are clustered by firm and calendar quarter. The excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. Option Above equals the average IV spread/skew of the previous week if it is above the median and 0 otherwise. Option Below equals the average IV spread/skew of the previous week if it is below the median and 0 otherwise. Eventday is a dummy variable that equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Size is the natural logarithm of firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Excess return			
	IV spread		IV skew	
Intercept	0.019**	0.038**	0.019*	0.060***
	(2.08)	(2.15)	(1.77)	(3.32)
Option Above	0.298**	0.410***	-0.231***	-0.254***
	(2.00)	(4.77)	(-4.37)	(-5.39)
Eventday*Option Above	-0.515**	-0.345	-0.267**	-0.237**
	(-2.15)	(-1.53)	(-2.37)	(-2.21)
Option Below	0.555***	0.500***	-0.113	-0.313***
	(6.44)	(8.10)	(-0.76)	(-3.50)
Eventday*Option Below	0.950***	0.940***	0.029	-0.180
	(3.52)	(3.41)	(0.14)	(-0.87)
Size		-0.001		-0.002
		(-0.23)		(-0.46)
B/M		0.0002**		0.0001
		(2.24)		(0.75)
Momentum		-0.007		-0.009
		(-0.38)		(-0.45)
Volatility		0.150		-0.455
		(0.20)		(-0.58)
Turnover		-0.041		-0.135
		(-0.35)		(-1.17)
Hskew		0.010***		0.013***
		(3.50)		(3.95)
Stock bid-ask spread		-0.007		-0.010
		(-0.59)		(-0.72)
Year FE	No	Yes	No	Yes
N	7,382,894	6,284,062	4,627,618	3,939,824
Adj R2 (%)	0.04	0.12	0.02	0.10

Table 8: Options market liquidity and options trading predictability

This table shows the effects of option bid-ask spread as a proxy for the options market illiquidity. Standard errors are clustered by firm and calendar quarter. Excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. Option refers to the IV spread and the IV skew. IV spread is the average IV spread over the previous week. IV skew is the average IV skew over the previous week. Eventday is a dummy variable that equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Optbasp is the option bid-ask spread, calculated as the best offer price less the best bid price scaled by the midpoint, averaged over the previous week. Size is the natural logarithm of the firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the past six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Excess return			
	IV spread		IV skew	
Intercept	0.014	0.037**	0.014	0.059***
	(0.96)	(2.07)	(1.00)	(3.35)
Option	0.471***	0.687***	-0.266***	-0.441***
	(10.62)	(9.07)	(-4.85)	(-5.34)
Option*Optbasp	0.005	-0.422***	0.022	0.237***
	(0.25)	(-5.61)	(0.97)	(3.54)
Eventday*Option	0.953***	0.855**	-0.410**	-0.327**
	(2.74)	(2.57)	(-2.30)	(-2.16)
Eventday*Option*Optbasp	-0.893**	-0.622*	0.370**	0.221**
	(-2.50)	(-1.92)	(2.37)	(2.00)
Size		-0.0004		-0.001
		(-0.10)		(-0.21)
B/M		0.0002**		0.0001
		(2.23)		(0.69)
Momentum		-0.007		-0.010
		(-0.34)		(-0.48)
Volatility		0.149		-0.358
		(0.20)		(-0.46)
Turnover		-0.030		-0.109
		(-0.26)		(-0.95)
Hskew		0.010***		0.013***
		(3.52)		(3.90)
Stock bid-ask spread		-0.007		-0.010
		(-0.62)		(-0.69)
Year FE	No	Yes	No	Yes
N	7,380,914	6,282,734	4,626,611	3,939,199
Adj R2 (%)	0.03	0.12	0.02	0.11

Table 9: Options trading measures in post-event period

The table below provides pooled OLS regressions of the post-event options trading proxies on the event day stock returns. Regressions are conducted for sub-samples of three types of events separately. Standard errors are clustered by firm and calendar quarter. Post-proxy takes the value of post-spread/ post-skew, which are the average IV spread/skew over the post-event week, expressed in percentages. Pre-proxy takes the value of the average IV spread/skew over the pre-event week expressed in percentages. Values of the IV spread/skew are expressed in percentage form. Ret 0 is the stock return on the event day. Size is the natural logarithm of the firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Post-proxy					
	Recommendation change		Forecast revision		Earnings announcement	
	IV spread	IV skew	IV spread	IV skew	IV spread	IV skew
Intercept	-1.494***	9.396***	-1.366***	9.249***	-0.821*	11.854***
	(-4.81)	(13.71)	(-3.89)	(14.83)	(-1.88)	(14.20)
Ret 0	-3.223***	1.134***	-3.148***	1.184**	-4.280***	0.835
	(-6.59)	(2.59)	(-5.60)	(2.39)	(-8.53)	(1.46)
Pre-proxy	0.457***	0.491***	0.482***	0.501***	0.393***	0.425***
	(19.91)	(31.95)	(28.90)	(21.45)	(20.55)	(24.27)
Size	0.062***	-0.308***	0.060***	-0.316***	0.031*	-0.379***
	(4.44)	(-10.80)	(3.84)	(-12.35)	(1.77)	(-10.50)
B/M	0.002	-0.004	-0.009	0.041	-0.004	0.059
	(1.59)	(-1.13)	(-0.91)	(1.58)	(-1.42)	(1.19)
Momentum	-0.115*	-0.411***	-0.032	-0.524***	-0.084*	-0.385***
	(-1.75)	(-4.52)	(-0.53)	(-5.53)	(-1.65)	(-4.99)
Volatility	-7.466***	14.650***	-11.040***	20.626***	-4.370**	14.967***
	(-2.74)	(2.87)	(-3.65)	(4.45)	(-2.53)	(2.86)
Turnover	-0.522	-3.222	-0.013	-9.197***	-6.231***	-9.525***
	(-0.44)	(-1.41)	(-0.01)	(-3.85)	(-3.18)	(-3.72)
Hskew	-0.077***	0.101***	-0.094***	0.012	0.030	0.059**
	(-4.68)	(3.86)	(-4.45)	(0.51)	(1.33)	(2.01)
Stock bid-ask spread	-0.006	0.163**	0.006	0.164**	-0.054	0.339***
	(-0.15)	(2.57)	(0.16)	(2.14)	(-1.09)	(4.98)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	105,314	68,982	180,709	126,563	72,051	42,429
Adj R2 (%)	21.38	28.66	23.97	30.97	17.06	25.09

Table 10: Four-factor analysis on long/short portfolios

This table displays the four-factor abnormal returns for long/short portfolios formed by sorting on the IV spread and IV skew. We divide the whole sample into an event group and a no-event group, based on occurrences of analyst recommendation changes, analyst forecast changes, or earnings announcements. For each sub-sample, stocks are sorted into decile portfolios every trading day, based on the average IV spread or IV skew over the previous week. Abnormal returns during the post-formation week with regard to the four Fama-French (1993) and Carhart (1997) factors are calculated for the value-weighted long/short portfolios, which long stocks in the top decile and short in the bottom decile. Alpha is the four-factor abnormal return obtained, expressed in percentages. Rm – Rf, SMB, HML, and Momentum are the four factors of the market excess return, the small-minus-big, the high-minus-low, and the momentum. The Newey-West (1987) t-statistics are computed to adjust for the autocorrelations. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: High - low			
	IV spread		IV skew	
	Event	No-event	Event	No-event
Alpha	0.145***	0.084***	-0.063**	-0.052***
	(5.18)	(7.09)	(-2.26)	(-4.21)
Rm – Rf	-0.043**	-0.012*	-0.035	-0.004
	(-2.40)	(-1.67)	(-1.44)	(-0.48)
SMB	-0.016	-0.013	0.036	0.022
	(-0.37)	(-0.79)	(0.71)	(1.41)
HML	0.041	-0.034***	0.086*	0.079***
	(1.01)	(-2.58)	(1.76)	(4.61)
Momentum	-0.020	-0.036***	-0.099***	-0.073***
	(-0.57)	(-2.90)	(-3.21)	(-6.01)
N	3,665	3,774	3,567	3,774
Adj R2 (%)	0.11	0.79	0.68	5.17

Table 11: When does the O/S ratio predict stock returns?

The following table shows pooled daily regressions of excess returns on the O/S ratio and its interaction terms with dummy variables which indicate occurrences of analyst-related/earnings-related events. Estimated standard errors are clustered by firm and calendar quarter. Excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. Absolute excess return is the absolute value of the excess return expressed in percentages. O/S is the average options trading volume over the stock trading volume for the previous week. Eventday is a dummy variable that equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Size is the natural logarithm of the firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return for the previous six months. Volatility is the daily equity return volatility in the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variables			
	Absolute excess return		Excess return	
Intercept	0.593***	0.593***	0.036**	0.036**
	(16.20)	(16.13)	(2.04)	(2.04)
O/S	0.627***	0.521***	-0.080***	-0.075***
	(10.27)	(9.27)	(-2.96)	(-2.77)
Eventday* O/S		1.501***		-0.071*
		(5.59)		(-1.90)
Size	-0.137***	-0.138***	-0.003	-0.003
	(-23.71)	(-23.87)	(-0.78)	(-0.76)
B/M	-0.003**	-0.003**	0.0002*	0.0002*
	(-2.25)	(-2.25)	(1.94)	(1.94)
Momentum	0.041	0.042	-0.014	-0.014
	(0.86)	(0.87)	(-0.75)	(-0.75)
Volatility	34.221***	34.211***	0.306	0.306
	(25.90)	(25.92)	(0.40)	(0.40)
Turnover	3.362***	3.337***	-0.068	-0.067
	(3.98)	(4.00)	(-0.62)	(-0.61)
Hskew	-0.038***	-0.038***	0.009***	0.009***
	(-9.06)	(-9.04)	(3.37)	(3.37)
Stock bid-ask spread	-0.038***	0.0003	-0.001	-0.001
	(-9.06)	(0.02)	(-0.15)	(-0.14)
Year FE	Yes	Yes	Yes	Yes
N	6,857,223	6,857,223	6,857,223	6,857,223
Adj R2 (%)	35.07	35.13	0.09	0.09

Table 12: Alternative options trading proxies

This table presents robustness checks using alternative options trading proxies. Pooled OLS regressions are conducted for the IV spread and IV skew separately. Standard errors are clustered by firm and calendar quarter. Excess return is the stock return in excess of the market return averaged over day t to day t+4, expressed in percentages. Option Premonth is the average level of the IV spread/skew over the previous month. Option Change is the change in the average weekly IV spread/skew. Eventday is a dummy variable that equals 1 if at least one of the analyst recommendation change, the analyst forecast revision, or the earnings announcement takes place on day t. Size is the natural logarithm of firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Excess return			
	IV spread		IV skew	
Intercept	0.037**	0.032*	0.053***	0.039**
	(2.08)	(1.76)	(3.04)	(2.06)
Option Premonth	0.332***		-0.174***	
	(4.35)		(-2.75)	
Eventday*Option Premonth	0.806***		-0.256**	
	(3.44)		(-2.37)	
Option Change		0.354***		-0.256***
		(8.27)		(-6.53)
Eventday*Option Change		0.263**		-0.147
		(2.08)		(-0.85)
Size	-0.0005	0.001	-0.001	0.0003
	(-0.13)	(0.14)	(-0.30)	(0.07)
B/M	0.0002**	0.0002**	0.0001	0.0001
	(2.23)	(2.23)	(0.72)	(0.21)
Momentum	-0.008	-0.007	-0.009	-0.007
	(-0.39)	(-0.36)	(-0.43)	(-0.34)
Volatility	0.101	0.081	-0.458	-0.533
	(0.13)	(0.11)	(-0.59)	(-0.69)
Turnover	-0.037	-0.077	-0.122	-0.114
	(-0.32)	(-0.66)	(-1.05)	(-0.87)
Hskew	0.009***	0.009***	0.013***	0.013***
	(3.39)	(3.23)	(3.94)	(3.72)
Stock bid-ask spread	-0.007	-0.008	-0.011	-0.012
	(-0.64)	(-0.66)	(-0.75)	(-0.81)
Year FE	Yes	Yes	Yes	Yes
N	6,284,062	6,000,711	3,939,824	3,447,141
Adj R2 (%)	0.09	0.10	0.09	0.10

Table 13: Earnings performance categorized by different levels of IV spread/skew

This table displays the mean of earnings performance for sub-samples categorized by the IV spread and the IV skew. For both the analyst recommendation change and the analyst forecast revision, stocks are sorted into quintiles based on the average IV spread or IV skew over the pre-event week. High refers to the top quintile with the highest IV spread/skew, and Low is the bottom quintile with the lowest IV spread/skew. SUE is calculated as the announced quarterly EPS less the corresponding consensus analyst forecast and scaled by the standard deviation of the quarterly earnings estimates. Preceding SUE is the mean of the most recent SUE that precedes each analyst-related event. N is the number of events for each quintile. The column High-Low reports the difference in the mean of Preceding SUE between high and low IV spread/skew sub-samples.

		IV proxy quintiles					
		High	(4)	(3)	(2)	Low	High-Low
Panel A: IV spread quintiles							
Analyst recommendation change	Preceding SUE	-0.089%	0.036%	0.060%	0.051%	-0.042%	-0.047%
	t-stat	(-4.66)	(2.97)	(6.40)	(5.79)	(-2.28)	(-1.81)
	N	21,500	21,721	22,082	21,993	21,478	
Analyst forecast revision	Preceding SUE	-0.076%	0.062%	0.070%	0.060%	0.010%	-0.086%
	t-stat	(-4.98)	(6.36)	(12.92)	(9.32)	(0.76)	(-4.29)
	N	39,072	39,688	39,956	39,911	39,280	
Panel B: IV skew quintiles							
Analyst recommendation change	Mean SUE	0.051%	0.084%	0.073%	0.052%	-0.019%	0.070%
	t-stat	(4.20)	(15.47)	(8.94)	(4.45)	(-1.28)	(1.55)
	N	15,288	15,593	15,902	15,902	15,799	
Analyst forecast revision	Mean SUE	0.074%	0.096%	0.100%	0.079%	-0.003%	0.077%
	t-stat	(11.02)	(18.31)	(11.50)	(11.43)	(-0.26)	(5.80)
	N	29,599	29,845	29,778	29,760	29,515	

Table 14: Can the IV spread/skew predict analyst initiations?

This table shows results of pooled OLS regressions of analysts' initial recommendations on the IV spread/skew. Estimated standard errors are clustered by firm and calendar quarter. Initial recommendation is the very first recommendation issued by an analyst on a stock. Option refers to the IV spread and the IV skew. IV spread is the average IV spread over the previous week. IV skew is the average IV skew over the previous week. Size is the natural logarithm of firm market capitalization. B/M is the book-to-market ratio. Momentum is the stock return over the previous six months. Volatility is the daily equity return volatility for the previous month. Turnover is the stock trading volume over the number of shares outstanding. Hskew is the historical daily stock return skewness of the previous month. Stock bid-ask spread is the closing bid-ask spread of the underlying stock, which is the closing ask less the closing bid and divided by the midpoint. Year FE refers to the controlling of the year fixed effects. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% level, respectively.

	Dependent variable: Initial recommendation			
	IV spread		IV skew	
Intercept	-2.245***	-2.244***	-2.183***	-2.236***
	(-82.66)	(-48.33)	(-69.39)	(-45.93)
Option	0.315	0.569***	-0.820***	-0.506***
	(1.55)	(4.05)	(-5.53)	(-5.09)
Size		-0.030***		-0.030***
		(-6.09)		(-5.42)
B/M		-0.001		-0.002
		(-1.37)		(-1.63)
Momentum		0.128***		0.093***
		(6.78)		(5.96)
Volatility		-0.880*		-0.521
		(-1.77)		(-1.11)
Turnover		-0.947**		-1.061**
		(-2.21)		(-2.32)
Hskew		0.013***		0.007
		(2.83)		(1.41)
Stock bid-ask spread		-0.029***		-0.007
		(-3.22)		(-0.65)
Year FE	No	Yes	No	Yes
N	72,001	63,014	51,118	45,190
Adj R2 (%)	0.02	5.14	0.31	5.73