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ABSTRACT

Using a broad sample of earnings announcements, we find a monotonic increase in the spread between call and put implied volatilities as it gets closer to the earnings announcement date. The steady build-up of volatility spread in the days leading up to the announcement date, coupled with the predictive power of cumulative abnormal implied volatility spread on subsequent announcement returns, suggests that informed traders are the driving force behind the option market activities prior to earnings announcements. Such informed trading, as proxied by the abnormal implied volatility spread, *increases* rather than *decreases* the stock market response to earnings announcements after controlling for an array of firm and announcement characteristics. This effect is most pronounced when the pre-earnings option trading volume is heightened. Overall, our findings lend strong support to the notion that informed options trading immediately before earnings announcements helps alleviate the stock market under-reaction to earnings announcements and make it closer to a complete response.

Keywords: implied volatility spread, earnings response coefficients, under-reaction correction

JEL Classifications: G10, G14

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Volatility Spread and Stock Market Response to Earnings Announcements

1. Introduction

Whether the stock market responds efficiently to corporate earnings announcements (EAs) is of great importance to the long-lasting theme of market efficiency. This paper examines how options trading affects the stock market reaction to EAs. Earlier studies have primarily used options listing status to examine how the stock market responds to EAs in the presence of options (Jennings and Starks 1986; Skinner 1990; Damondaran 1991; Fedenia and Grammatikos 1992; Ho 1993; Ho et al. 1995). As options listing becomes more prevalent, recent studies have switched from options listing status to options trading volume and focused on the informational content of options trading volume (Amin and Lee 1997; Easley et al. 1998; Cao et al. 2005; Pan and Poteshman 2006; Roll et al. 2010).

While these studies greatly enhance our understanding of the economic consequences of options trading, they suffer from several major drawbacks. Using options listing status creates a simple dichotomy – optioned stocks vs. non-optioned stocks – and ignores the heterogeneity of varying degree of options trading activities. Focusing on options trading volume and associating it with informed trading, on the other hand, require either high-frequency options trade and quote data to sign the option volumes (Amin and Lee 1997; Cao et al. 2005) or proprietary datasets to construct the volume-based predictive variables (Pan and Poteshman 2006). Unfortunately, the high-frequency options trade and quote data or proprietary options trading data are not publicly available.

It is worth noting that very few papers have examined the informational content of option pricing effects, especially around significant corporate events. This paper attempts to fill the void by investigating the option pricing effects. To be more specific, we employ the option implied volatility spread to examine the implication of options trading on stock market response to EAs. We argue that this new perspective not only enables us to get around the data availability issue but also sheds new light on the change in stock market response because of options trading.

Using a broad sample of EAs, we find that option call and put implied volatilities become increasingly misaligned as the earnings announcement dates (EAD) get closer. The percentage deviation between call and put implied volatilities increases monotonically during the month prior to the EAD. The direction of these deviations is also consistent with the sign of announcement returns of subsequent earnings releases. Moreover, the abnormal volatility spread has significant predictive power on the subsequent announcement returns. We interpret these findings as evidence consistent with informed options trading before EAs.

We then proceed to analyze how informed options trading immediately before EAs affect the stock market response. Availing ourselves of the earnings response coefficient (ERC) framework, we are able to quantify the exact magnitude of the stock market response. We find that pre-earnings options trading *increases* rather than *decreases* the stock market response to earnings announcements. To the extent that there exists stock market under-reaction to EAs, pre-earnings options trading helps mitigate the stock market under-reaction. In the cross section, firms experiencing greater abnormal implied volatility spread immediately before the EAD exhibit stronger stock market reactions after controlling for a myriad of firm characteristics.

We further conjecture that the under-reaction correction effect should be stronger for those announcements that have experienced higher pre-earnings options trading volume. The options trading volume can play a significant role in the stock market response to EAs through at least two channels. First, the strategic trading models in the spirits of Kyle (1985) argue that it is desirable for informed traders to hide their information-based trades among liquidity trades. To the extent that higher pre-earnings option trading volume provides better camouflages, there can be more concentrated informed options trading immediately before EAs. Second, to the extent that trading volume proxies for investor attention, higher pre-earnings option trading implies increased investor attention. The fact that investors become more attentive prior to EAs certainly helps mitigate the stock market under-reaction. Given that informed options trading accelerates the stock market response, we expect greater under-reaction correction effect in the presence of higher pre-earnings options trading volume. This is precisely what we find in the data.

This paper touches upon at least three streams of literature: on EAs, on stock market response to EAs, and on the earnings response coefficient (ERC) framework. On the first strand of empirical literature, EAs have received increased attention from both academia and practitioners due to their information-intensive nature, and have been routine channels through which firms disclose material information to financial markets. The existing literature has well documented two stylized facts about EAs: stock market under-reaction at the time of announcements and post-earnings announcement drift (PEAD), which refers to the phenomenon that the stock price tends to continue drifting in the direction of the earnings surprise. [5]

This paper is closely related to both stylized facts. By tying options implied volatility spread to stock market responses to earnings announcements, we show that pre-earnings options trading is associated

[5] The post-earnings announcement drift anomaly has proved to be one of the strongest anomalies in the literature and many researchers have worked on this issue, including Ball and Brown (1986), Bernard and Thomas (1989, 1990), Bhushan (1994), Dontoh et al. (2003), Mendenhall (2004), Sadka (2006), Livnat and Mendenhall (2006), Ng et al. (2008), Sadka and Sadka (2009), Chordia et al. (2009), Konchitchki et al. (2012), among others.

with an *increase* rather than a *decrease* in stock market responses to earnings releases. This contradicts the earlier findings (Skinner 1990; Ho 1993) that options listing decreases the stock market response. However, our paper supports Mendenhall and Fehrs (1999) who also document an increase in the stock market response following the introduction of options listing. Instead of focusing on the binary outcomes of options listing status, we are able to go further than Mendenhall and Fehrs (1999) and examine the varying degree of options trading activities. Specifically, we develop and test the hypothesis that the presence of active options trading can at least alleviate (or partially correct) the stock market under-reaction at the time of announcements.

This paper also contributes to the literature on post-earnings announcement drift. By resorting to options trading volume as a proxy for investor attention, we propose that in addition to the information preemption argument as discussed in the existing literature, there is an alternative mechanism through which investor attention in the options market can increase the stock market reaction at the time of announcements and reduce the post-earnings announcement drift. That is, pre-earnings options trading can actually help attenuate the stock market under-reaction. The net effect of pre-announcement options trading on stock market response depends on the relative dominance of the information preemption and under-reaction correction. By examining the options trading volume in the context of PEAD, we provide additional support for the under-reaction correction hypothesis among firms with the presence of active options trading.

Our paper also connects the informed options trading literature to the literature on stock market response to earnings announcements. One emerging strand of the options trading literature examines the informational content of implied volatility spread (Bali and Hovkimian 2009; Xing et al. 2010; Cremers and Weinbaum 2010). While there has been ample evidence that implied volatility spread has significant predictive power on future stock returns during normal times, very few studies examine whether and how implied volatility spread pertains to future stock returns around significant corporate events such as routine earnings announcements. This paper examines the patterns of implied volatilities immediately before earnings announcements and studies its relation to stock market reactions to releases of earnings.

Like Turong and Corrado (2014), we examine in this paper implications of options trading on stock market response to earnings announcements. A main distinction between our paper and Turong and Corrado (2014) lies in our focus on both implied volatility spread and options trading volume. We argue that volatility spread provides a cleaner and more powerful metric for the nature of pre-earnings options trading than unsigned options trading volume, which may lead to contaminated inferences.

This paper also updates the earnings response coefficient (ERC) framework. We embed the volatility spread metric into this framework to examine the stock market response to significant corporate information events. This novel design allows us to have a more complete picture of how varying degree of options trading affects the stock market response. To the best of our knowledge, this is the first paper that connects the volatility spread metric to the earnings response coefficient literature.

The rest of the paper is organized as follows. We survey the related strands of literature in Section 2 and develop the empirical hypotheses in Section 3. The data and methodology used in this paper are discussed in Section 4. Section 5 presents the main empirical findings of this paper. Two sets of robustness check on the empirical design of key variables are conducted in Section 6. We conclude in Section 7.

2. Literature review

In this section, we briefly review the existing literature about the stock market response to EAs in the presence of options trading. Our literature review is centered around two closely related research themes: the informed options trading literature and the ERC literature to quantify the stock market reaction.

2.1. Informed options trading literature

In the Black-Scholes (1973) framework, options are redundant derivatives since their payoffs can be replicated by the underlying securities in complete markets and their values derive from the underlying assets. Consequently, options trading should convey no new information to the market participants. However, in the absence of complete markets, options may no longer be redundant. Coupled with features such as low costs, high leverages and absence of short-sales constraints, informed traders can view options as superior investment vehicles and choose to trade options to capitalize on their private information. Consequently, price discovery takes place in the options market and options trading enhances informational efficiency in the underlying stock market. Consistent with this argument, Chakravarty, Gulen and Mayhew (2004), among others, document supporting evidence that the options market contributes about 17 percent of the stock price discovery.

As options listing became increasingly prevalent over recent years, subsequent studies focus on the informational content of options trading. Along this line researchers have focused primarily on the informational content of options volume. Amin and Lee (1997) document unusual options market activity immediately before earnings announcements. They further show that option traders initiate a greater proportion of long (short) positions before positive (negative) earnings news. Easley et al. (1998) construct a theoretical model for trading volume in the options market and argue that options trading is informative about future stock prices since more sophisticated traders with private information choose to trade options first. Cao et al. (2005) confirm the price discovery role of the options market by showing that the takeover targets with the largest increases in pre-announcement call-imbalance experience the highest announcement-day returns. Pan and Poteshman (2006) present strong evidence that their constructed put-call ratio predicts future stock returns. Roll, Schwartz and Subrahmanyam (2010) show that their proposed options to stock volume ratio (O/S) is higher around earnings announcements. They also demonstrate that post-announcement absolute returns are positively related to pre- announcement O/S, which they interpret as supportive evidence that at least part of the pre-announcement options trading is informed. Johnson and So (2012) find that the O/S ratio also predicts future firm-specific earnings news, consistent with O/S reflecting private information.

Albeit insightful, the options trading volume as the main metric for informed trading in the existing literature has its limitations, often requiring either high-frequency data on options trades and quotes or proprietary data. For instance, both Amin and Lee (1997) and Cao et al. (2005) employ the Berkeley Options Database, which covers time-stamped options trades and quotes from 1976 to 1995. In comparison, Pan and Poteshman (2006)'s construction of the put-call ratio requires a proprietary dataset that is not publicly available. In this paper, we advocate using implied volatility spread instead to address the data availability issue.

A growing strand of literature has turned to implied volatilities and volatility spread to infer information about the underlying stock. Implied volatility spread is defined as the difference between call implied volatility and put implied volatility, where call options and put options are matched on strike prices and maturities. Under perfect market conditions and for a given strike price and maturity combination, call implied volatility should be the same as the put implied volatility since both of them are measuring the forward-looking volatility of the same underlying stock. Directional move of the underlying stock price, however, can cause significant deviations of the call implied volatility from the put implied volatility. For instance, positive information about the underlying stock can drive up the demand for and the prices of calls as opposed to puts. The relative pricing pressure on calls translates into more expensive calls, and thus higher call implied volatilities. Similarly, negative information induces more expensive puts, leading to higher put implied volatilities.

A few influential studies have demonstrated that implied volatility spread has strong predictive power on the future stock returns. Bali and Hovkimian (2009) document that the call-put implied volatility spread reflects the future price increase of the underlying stock. Cremers and Weinbaum (2010) show that deviations from put-call parity contain information about future stock returns beyond short sales constraints. Stocks with relatively expensive calls (higher call implied volatilities relative to put implied volatilities) outperform stocks with relatively expensive puts by 50 basis points on a weekly basis. Such predictability is robust to the firm size and varies with option liquidity and the underlying stock liquidity. Xing et al. (2010) examine the predictive power of a variation of volatility spread, i.e., the volatility smirk among a cross section of stocks.[6] They find that stocks exhibiting the steepest smirks in their traded options underperform stocks with the least pronounced volatility smirks in their traded options by 10.9 percent on an annual basis after risk adjustment.

It is worth pointing out that most of the extant studies on volatility spread has primarily focused on the forecasting power during regular times and along the time series dimension. We turn to one of the most important corporate information events: the earnings announcements. We are able to verify and reinforce the predictive power of volatility spread around such special time windows using a cross section of EAs.

2.2. Stock market response to EAs and the ERC literature

One related strand of literature focuses on the implications of options listing on the underlying stock market. Several papers have shown that options listing greatly enriches the information environment of the stock market and contributes to stock price informativeness. Jennings and Starks (1986) demonstrate that the optioned stocks adjust much faster to earnings announcements as compared to non-optioned stocks. Skinner (1990) documents a dramatic increase in analyst following one year after the introduction of options listing and argues that this indicates more private information becoming available in the market. Damodaran (1991) and Ho (1993) document a significant increase in institutional holdings after options listing. Ho (1993) also shows that optioned firms receive about 50 percent more news coverage by the Wall Street Journal than non-optioned firms. Ho et al. (1995) show that the analyst forecast accuracy increases significantly after options listing. Kumar et al. (1998) provide supportive evidence of options listing improving the market quality of the underlying stocks – a decrease in the bid-ask spread and an increase in quoted depth, trading volume, trading frequency and transaction size of the underlying stock. It is now generally agreed that options listing leads to greater information acquisitions as well as more efficient information processing, thus making the stock price more informative.

Another line of research focuses on the role of options listing when examining the relationship between the stock price reaction to earnings announcements and economic variables that capture or relate to information production and revelation surrounding earnings announcements. The intuition is that stock price reaction to an earnings announcement should be smaller for firms with more information production and revelation through financial press coverage (Grant 1980), firm size (Atiase 1985; Freeman 1987; Collins et al. 1987), and analyst attention (Dempsey 1989; Lobo and Mahmoud 1989;

[6] Volatility smirk is defined as the difference between implied volatilities of out-of-the-money put options and at-the-money call options.

Shores 1990) because more of the potential information contained in earnings has been preempted (Atiase 1994).

Skinner (1990) examines the role of options listing using the widely studied stock return-earnings framework and tests for changes in the stock's earnings response coefficient, defined as the estimated regression slope for a variable such as standardized unexpected earnings (*SUE*) explaining abnormal return at the time of earnings announcements. He finds a smaller earnings response coefficient after options listing. Ho (1993) and Ho et al. (1995) further confirm the reduction in earnings response coefficients due to options listing.

However, Mendehall and Fehrs (1999) argue that the decrease in the stock-price response to earnings, as documented by Skinner (1990), may result from concurrent changes in firm size and changing market conditions. Using 420 firms initiating options trading during 1973-1993, they find that firms initiating options trading after 1986 fail to exhibit a significant decline in the earnings response. They further provide evidence that options listing may actually increase the stock price response to earnings, contrary to the findings from prior studies.

The options listing status may not be the most effective gauge for the stock price response to earnings releases for two reasons. First, options listing can be endogenous. Systematic changes to the firms and market conditions can drive both options listing and changes in the informational content of firms' earnings announcements. As Skinner (1990) points out, *"… optioned firms change in systematic ways between pre- and post-listing periods. It is possible that these systematic changes are related to the options exchanges' decision to list the firm and to the observed change in the information content of these firms' earnings releases. In other words, options listing is endogenous, which makes it difficult to conclude that options listing causes changes in the information content of these firms' earnings releases."*

Second, the binary outcomes form using options listing status (firms with listed options versus firms without listed options) overlook the heterogeneity of options trading among firms with listed options. The options trading activities can be infrequent for some firms but very active for others. The information role of options may vary significantly depending on how easily informed trades can exploit trading opportunities in options. Consequently, inferences based on this dichotomy implicitly assume that the benefits of trading options are homogeneous across optioned firms. Where options trading volume is thin, the implication of options listing may be closer to the case without options listing. Admati and Pfleiderer (1988) point out that if options markets have insufficient trading volumes, informed traders would find no advantage to trade options. Roll et al. (2009) concur with this argument and emphasize that, *"…it can be argued that ceteris paribus, markets for claims in firms with higher options trading volume should be more informationally efficient and thus valued more highly. It is worth noting that mere* *listing an option does not necessarily imply a valuation benefit … Any valuation benefit of options listing should depend on substantial trading activity.*"

In this paper, we rely on the use of volatility spread to capture informed trading in the options market while at the same time examine the confounding effects of varying degrees of the options market trading activities. Such an approach is not only more up-to-date but also allows us to gain significant insights into the economics of options trading on the stock market response to EAs.

3. Hypothesis Development

3.1. Speculative versus informed trading hypothesis

Earnings announcements provide an ideal setting to investigate the motives and implications of pre-announcement options trading. Earnings announcements are regularly scheduled corporate events. Investors anticipate the earnings announcement date (EAD) in advance and firms typically refrain from postponing announcements to avoid unfavorable market response. [7] Arguably, the scheduled announcement dates promote speculative trading prior to these announcements. Moreover, earnings announcements can be rich in information that moves the market. Prior to the announcements, uncertainty about the upcoming announcements builds up and does not get resolved until announcements are actually made. During an earnings release, firms often announce how they have performed in the most recent quarter, which may or may not be consistent with market expectations. Any slight difference between the market consensus estimate of earnings per share (EPS) and the actual EPS could generate substantial market reactions.[8] In addition, firms usually revise and update their outlook for future quarters, often leading to market price revisions. The information intensity generates substantial trading interest from both speculative and informed investors prior to the earnings announcements.

The market-moving potential of earnings announcements, combined with unique features of options trading such as high leverage, induces investors to trade options before such announcements. Not surprisingly, two alternative hypotheses have been proposed to explain the pre-announcement options trading: speculated trading hypothesis and informed trading hypothesis. The speculated trading hypothesis postulates that speculative traders choose to establish their options position in advance, attempting to profit from the subsequent move in the underlying stock price when the announcement is made and the uncertainty is resolved. In contrast, the informed trading hypothesis argues that strategic

[7] Bagnoli et al. (2002) show that any delay in scheduled earnings announcements leads to significantly negative stock price reactions and economic losses for such firms, a situation they refer to as "a day late, a penny short".

[8] For example, on September 28, 1998, former SEC Chairman Arthur Levitt delivered a speech entitled "The 'Numbers Game'" in which he mentioned a company that missed its numbers by a single penny lost 6 percent of its stock value on a single day.

traders, who are privately informed about upcoming announcements regarding the firms' current or future performance, engage in options trading to capitalize on their private information.

While it is difficult for researchers to disentangle these two different trading motives ex ante, implied volatility spread provides an ideal metric to detect and identify informed trading prior to earnings announcements. Clearly the sign of this measure can be verified ex post against earnings announcements to validate the informativeness of options trading, as positive (or negative) volatility spread should precede positive (negative) news on earnings under the informed trading hypothesis. Speculative trading lacks this directional view in contrast. Existing studies rely on the association between the stock return skewness in previous quarter and the put-call volume ratio to test the speculative trading hypothesis (Alldredge et al. 2011). Using implied volatility spread in this paper makes it possible to conduct a clean and direct test on whether pre-announcement options trading is predominantly driven by informed traders.

If earnings announcements contain market-moving information and pre-announcement options trading is driven by informed traders, then trades by these informed traders will certainly exert pricing pressure on calls and puts. Consequently, there are likely more occurrences of deviations between the call and put implied volatilities immediately before earnings announcements as compared to normal times. In other words, we expect abnormal implied volatility spread before earnings announcements.

To support the informed trading hypothesis, the sign validation discussed earlier indicates that call implied volatility should exceed put implied volatility prior to positive earnings news, leading to an increase of implied volatility spread immediately before earnings announcements as opposed to normal times. In other words, we expect the deviations between call and put implied volatilities to be consistent with the nature of the information released in earnings announcements.

Our first hypothesis summarizes the above two implications.

Hypothesis 1a: If pre-announcement options trading is driven by informed traders, then there will be frequent occurrences of sizeable spread between call and put implied volatilities immediately before the earnings announcements.

Hypothesis 1b: If the implied volatility spread is a measure of informed trading, then it should be consistent with the direction and magnitude of new information revealed by the earnings announcements.

3.2. Stock market response to EAs

We next examine how pre-announcement options trading affects the way the stock market responds to the information released through EAs. For this exercise, we follow the literature and adopt the earnings response coefficient (ERC) framework.[9] In this framework researchers often employ the announcement return to proxy for the stock market reaction and the standardized unexpected earnings (*SUE*) to proxy for the amount of new information.[10] Regressing the announcement return on *SUE* helps uncover the magnitude of stock market responses. A positive and statistically significant estimated slope for *SUE* is interpreted as a strong stock market response to the earnings release.

The ERC framework is intuitive yet flexible enough to accommodate the addition of interaction terms between *SUE* and additional variables of particularly interest to researchers. The set of explanatory variables can include dummy variables taking the value of 1 for certain firm characteristics and 0 otherwise. For instance, when examining the effect of options listing on the informational efficiency of the underlying stock price, researchers have included an interaction term between *SUE* and a dummy variable for options listing status (Skinner 1990; Mendenhall and Fehrs 1999; Turong and Corrado 2014). The use of interaction terms greatly facilitates the comparison of differentiated stock market responses to earnings news, thus allowing researchers to gauge the stock market responses across firms with different attributes. The caveat is that *SUE* is a noisy measure for new information and the ERC regression test may not have the desired statistical power.

3.2.1. Information preemption hypothesis

One may naturally anticipate the improvement of stock price efficiency, provided that pre-announcement options trading is indeed dominated by investors who are privately informed about the upcoming earnings announcements. Pre-announcement options trading by informed traders should help reveal at least part of their private information. The more active the pre-announcement options trading, the more information will be incorporated into stock prices prior to earnings announcements. Consequently, the magnitude of stock market response will be reduced upon announcement of earnings, since pre-announcement options trading has partially preempted the market-moving information in earnings. We refer to this argument as the *information preemption hypothesis.*

We test the intuition behind the ERC framework using the following regression design,

$$AnnRet = \beta_0 + \beta_1 \cdot SUE + \beta_2 \cdot SUE \cdot Opt\ Trading\ Variable + \sum_{k=3}^{K} \beta_k \cdot Control\ Variables + \varepsilon$$

[9] The ERC framework is widely used in accounting and financial research, including Skinner (1990), Ho (1993), Ho et al. (1995), Mendenhall and Fehrs (1999), Livnat and Mendenhall (2006), Truong et al. (2012), Truong and Corrado (2014), among others.

[10] There are at least three alternative measures of *SUEs*. In this paper we follow Livnat and Mendenhall (2006) and define *SUE* as the actual EPS minus the analyst consensus estimate, scaled by the closing price in the previous quarter. We conduct robustness check using the other two measures of *SUE* and the main results remain qualitatively the same.

Following Skinner (1990), we construct the announcement abnormal return (*AnnRet*) as follows. With the date of announcement denoted by t, we first estimate a market model over the window [t-210, t-31] for firm-level stock returns. Abnormal returns are then calculated as daily stock returns in excess of predicted daily returns based on the estimated market model. We cumulate the daily abnormal returns over the event window [t-1, t+1] to arrive at the announcement abnormal return *AnnRet*.

We follow Livnat and Mendenhall (2006) and define standardized unexpected earnings (*SUE*) as the actual reported earnings per share minus the median analyst forecast within 90 days prior to the earnings announcement date, scaled by the closing price in the previous quarter. The *SUE* variable is the main explanatory variable in the ERC framework.

In this regression we use implied volatility spread as the options trading variable. The implied volatility spread is a desirable metric in this context because it captures the pricing effects of options trading. In comparison, existing studies have typically used unsigned option volumes due to the lack of intraday option data on trades and quotes that are publicly available. The unsigned volume can potentially contaminate inferences about the informed trading hypothesis, thus the implied volatility spread can be a better proxy.

Several papers (Bali and Hovakimian 2009; Cremers and Weinbaum 2010) use the raw volatility spread to predict future stock price movement. Instead of relying on the level of implied volatility spread, we examine the change in the implied volatility spread during the period immediately before earnings announcements compared to normal times. This is more appropriate given our focus on gauging the incremental information revealed through the pre-announcement options trading.

3.2.2. Under-reaction correction hypothesis

One salient feature of earnings announcements is the well-documented PEAD anomaly in the literature. While there are alternative explanations for this anomaly, it is now generally accepted that the stock market underreacts to earnings releases for various reasons. Given that the stock market underreacts to earnings surprises, it is likely that pre-announcement options trading by informed traders helps alleviate this under-reaction and speeds up the stock price adjustment process. We refer to this argument as the *under-reaction correction hypothesis.*

The under-reaction correction hypothesis is a natural extension of the existing literature on the implications of options listing status and trading. There are several mechanisms through which the options market activities mitigate the stock market under-reaction. First, there is a transaction cost perspective. Fedenia and Grammatikos (1992) document evidence of a drop of about 20 percent in average bid-ask spread among NYSE firms that have just initiated options trading. Bhushan (1994) argues that transaction costs, along with differential abilities among investors to process information, can lead to investor under-reaction and post-earnings announcement drift. Mendenhall and Fehrs (1999) point out that while the uninformed trades tend to make the price deviate from the market-moving information in earnings releases, the informed trades move prices in the proper direction. It is thus plausible that higher pre-announcement options trading reduces equity transaction costs and relaxes the constraints among traders who are conscientious of transaction costs, thus providing camouflage for additional informed trades. The presence of more informed trades in turn moves the stock price closer to the right level, effectively reducing the stock market under-reaction to earnings announcements. Consistent with this view, Govindarajet al. (2012) argue that options traders are less susceptible to the under-reaction bias as compared to equity traders.

Second, there is a price discovery perspective. Options trading can reduce the market under-reaction by speeding up the price discovery process. Jennings and Starks (1986) document solid evidence that optioned firms adjust to the quarterly earnings releases much faster than non-optioned firms.

There is also an investor attention perspective. A number of studies of investor behavior have argued that, contrary to what standard economic models assume, investors' attention is limited. When investors do not pay enough attention to the information released in the earnings announcements, the stock market may under-react to the earnings announcements (Hou et al. 2009; Hirshleifer et al. 2009; Della Vigna and Pollet 2009). Consequently, active options trading immediately before earnings announcements may indicate increased investor attention, thus leading to under-reaction correction.

Overall, the pre-announcement options trading can have an effect contrary to the muted response under the information preemption hypothesis. The higher the pre-announcement options trading, the more likely that it accelerates the price discovery process and promotes market efficiency, thus making the stock market response more complete. In other words, the *under-reaction correction hypothesis* predicts a positive effect on the earnings response coefficients. Consequently, in the above regression framework, the slope coefficient estimate before the interaction terms is expected to be positive and significant.

Taken together, the effect of pre-announcement options trading on the stock market response is thus an empirical question. The information preemption hypothesis predicts a negative and significant sign whereas the under-reaction correction hypothesis predicts a positive and significant sign in the ERC framework. These two countervailing forces may even offset each other, leaving no detection of statistical significance. We thus leave the significance and signs before the interaction terms to be empirically determined by the data. Our second hypothesis formally summarizes the above discussion.

Hypothesis 2: If higher pre-earnings options trading mainly helps preempt information prior to the earnings announcement date, then stock market response should become weaker. On the other hand, if higher pre-earnings options trading mainly helps mitigate stock market under-reaction, then stock market response should be stronger.

3.3. The role of options trading volume

Our next hypothesis examines the implication of options trading volume. While existing studies have found evidence of the ability of the signed options trading volume to forecast future stock price movement, data limitations prevent us from using signed options trading volume as a proxy for informed trading. However, this does not necessarily imply that options trading volume is irrelevant in our context. On the contrary, options trading volume has at least two confounding effects on the under-reaction correction effect we hypothesize in the previous section. In what follows we elaborate on these two effects in more details.

The first confounding effect is the camouflage effect. Strategic trading models such as Kyle (1985, 1989), Admati and Pleiderer (1988), Holden and Subramanyam (1992), Foster and Viswanathan (1994, 1996), Huddart et al. 2001) argue that informed traders will try to hide their trades among liquidity trading so as to prevent their private information from being revealed fully and instantaneously. To the extent that higher pre-earnings options trading volume provides better camouflage, it is possible that higher options trading volume will induce more informed trading, and hence, the stock market under-reaction can be mitigated.

Another confounding effect is the investor attention effect. A stream of recent literature has argued for the use of options trading volume as a proxy for investor attention. In the following we branch out to discuss the latest development in this literature before formally introducing our next hypothesis.

The importance of human beings' attention dates back to at least Kahneman (1973), who points out that attention is a scarce cognitive resource and that there is a limit to the central cognitive-processing capacity of human brains. In recent years, researchers have focused on the implication of investors' limited attention in the financial markets. An increasing number of theoretical and empirical studies have shown that limited attention can cause investors to neglect useful information, thus leading to stock price under-reaction. Hirshleifer and Teoh (2005), Peng (2005), and Peng and Xiong (2006) have built theoretical models to show that when investors are subject to limited attention, they may ignore earnings announcements, resulting in stock price under-reaction to earnings releases. Consistent with this argument, Hirshleifer et al. (2009) and Della Vigna and Pollet (2009) have demonstrated that stock prices show weaker immediate reaction but stronger post-announcement drift for earnings announcements that are made on days when more firms announce their earnings or on Fridays during which market participants are usually less attentive to business.

While there are many empirical proxies for investor attention such as firm size and analyst coverage, trading volume has been proposed as a valid proxy. The intuition is simple but appealing. Active trading involves investors' attention in analyzing their portfolios and asset fundamentals. When investors pay less attention to a stock, it is less likely that they will trade. On the other hand, more investor attention, combined with behavioral biases such as overconfidence, may lead to heterogeneous opinions among investors and generate more trading. Some researchers have further argued that trading volume can be a superior proxy. Lo and Wang (2000) show that trading volume tends to be higher among large stocks which tend to attract more investor attention. Hou et al. (2009) point out that although size and analyst coverage approximate for the amount of information available in the public domain, how closely investors monitor the revelation of such information may be unrelated to size and analyst coverage. Chordia and Swaminathan (2000) show that even after controlling for size, high volume stocks tend to respond more quickly to market-moving information than do low volume stocks, suggesting the possibility that trading volume contains information about investor attention beyond firm size. Gervais, Kaniel and Mingelgrin (2001) demonstrate that the rising volume raises a stock's visibility and attracts more investor attention.

If investors' limited attention is at least partially captured by options trading volume, then higher pre-announcement options trading volume indicates increased investor attention before such announcements. The heightened investor attention immediately prior to earnings announcements can help alleviate the stock market under-reaction and make the stock market response more complete at the time of announcements.

Taken these two effects together, we expect a stronger under-reaction correction effect among earnings announcements with higher pre-announcement options trading volume. This intuition is summarized in Hypothesis 3.

Hypothesis 3: The under-reaction correction effect should be stronger among earnings announcements with higher pre-announcement options trading volume.

3.4. Post-earnings announcement drift effect

When discussing the implications of pre-announcement options trading on the abnormal announcement return in Section 3.2, we illustrated the contrast between the information preemption effect and the under-reaction correction effect. If pre-announcement options trading indeed helps reduce the stock market under-reaction to earnings news and makes the stock market response more complete, then the post-earnings announcement drift is naturally expected to be smaller among announcements corresponding to higher pre-announcement options trading. In other words, much of the under-reaction has been "corrected" by the informed options trading before such announcements.

To test this intuition, we focus on the post earnings announcement drift (PEAD) term instead of the abnormal announcement return as the dependent variable. To construct PEAD, we cumulate abnormal stock returns over the time window [t+2, t+91], where t denotes the earnings announcement date.

$$PEAD = \gamma_0 + \gamma_1 \cdot SUE + \gamma_2 \cdot SUE \cdot Opt\ Trading\ Variable + \sum_{k=3}^{K} \gamma_k \cdot Control\ Variables + \varepsilon$$

In the revised regression framework above, the explanatory variables include *SUE*, the interaction term between *SUE* and the options trading variable, as well as other control variables relevant for post earnings announcement drift. To be consistent with the under-reaction correction hypothesis, a negative value is expected for the estimated slope coefficient before the interaction term between *SUE* and the options trading variable. Hypothesis 4 formally summarizes the above intuition.

Hypothesis 4: If pre-announcement options trading at least partially corrects stock market under-reaction to earnings announcements, then a weaker post earnings announcement drift is expected among announcements with higher options trading prior to earnings news.

4. Data and Methodology

This study utilizes a number of data sources. Daily returns on individual stocks and the stock market index are retrieved from the Center for Research in Securities Prices (CRSP). We obtain financial information about the sample firms from Compustat. Institutional ownership data are extracted from Thomson Reuters Institutional Holdings (S34) database. Common firm identifiers such as CUSIP numbers and ticker symbols are used to match observations from different databases. In the rest of this section we focus on the details of constructing the final sample of optioned firms along with their earnings announcements.

4.1. Options data

Our options trading data come from the Ivy DB OptionMetrics database, which has evolved into the industry standard for options-related research with data available since January 1996. OptionMetrics provides the end-of-the-day summary data of option volumes as well as the best bid and best offer prices for each optioned stock with contracts distinguished by option class (call or put), strike price, and maturity.

OptionMetrics estimates implied volatility for each traded option contract utilizing a proprietary pricing algorithm based on the binomial tree model and iterating its numerical optimization until the model price of an option converges to the midpoint of best closing bid and best closing offer prices. These estimates of implied volatilities allow for underlying securities with dividend payments and early exercise possibilities, while carrying the strengths and weaknesses of the underlying model. We compute the implied volatility spread for a given stock as the difference between the implied volatility for call and put options with matching strike prices and maturities. This spread measure may reduce the noise in the implied volatilities given the convention of OptionMetrics of relying on the midpoint of the best closing bid and offer prices as the market price of a given option.

It has been reported that OptionMetrics contains a number of data errors.[11] We apply a number of filters to deal with the reported data errors contained in OptionMetrics. These data errors are mainly related to identical observations, zero best bid prices, and missing values for implied volatility.

4.2. Earnings announcement data

For data on earnings announcements, we primarily rely on the Institutional Brokers' Estimate System (I/B/E/S) database. The actuals file from the I/B/E/S database provides earnings announcements data, including firm names, firm identifiers and earnings announcement dates. Following Livnat and Mendenhall (2006), we apply a number of filters to the universe of the earnings announcements obtained from the I/B/E/S database. More specifically, the earnings announcement date reported in Compustat and I/B/E/S should not differ by more than one calendar day; the price per share is available from Compustat at each fiscal quarter end; the price is greater than $1; and the market and book values of equity at fiscal quarter end are available and are larger than $5 million.

We follow the standard ERC literature when constructing the main variables that are used in the empirical analysis. Two key variables, the cumulative announcement abnormal return (*AnnRet*) and the standardized unexpected earnings (*SUE*) are defined and discussed in Section 3.2. In addition, we also construct a number of control variables to capture firm- and event-specific characteristics while following the standard practice in the literature (Lei and Wang 2014). We compute the market capitalization for each firm (*Size*) as the natural log of shares outstanding multiplied by the closing price at the month end prior to the earning announcements. The pre-announcement stock price run-up (*Runup*) is defined as abnormal stock returns cumulated over $[t-30, t-2]$. It serves as a proxy for information leakage in the days immediately before corporate announcements. Past stock returns (*PastRet*) are defined as the buy-and-hold stock return cumulated over $[t-210, t-31]$. The book-to-market ratio (*BM*) is the book value of equity divided by the market value of equity calculated as of the previous fiscal quarter end. The institutional ownership ratio (*IOR*) is calculated as the shares held by institutional money managers who file 13(f) reports with the SEC divided by the number of shares outstanding as of the previous quarter. Our sample period covers from 1996 to 2015. A total of 128,438 earnings announcements survive all the filters after matching across variable databases. Table 1 describes summary statistics of these variables.

5. Empirical Analysis

5.1. Sizeable implied volatility spread immediately before earnings announcements

Under Hypothesis 1a, we expect a large spread between call and put implied volatilities occurring frequently when the pre-announcement options trading is driven by informed traders. After identifying

[11] Ofek et al. (2004) and Battalio and Schultz (2006) discuss the data errors in the OptionMetrics database.

sizeable spreads to ensure comparability across firms and events, we examine the fraction of sizeable spread during the 30-day period prior to the date of earnings announcement and check for any potential trend across six five-day windows over the same period.

What is considered a sizeable spread between call implied volatility and put implied volatility for one stock may not necessarily be large for a different stock. Even for the same stock, the magnitude of implied volatility spread can change over time. It has also been documented that relative to calls, puts appear to be more expensive than theoretical predictions, leading to an often negative estimate of implied volatility spread. Therefore, it is important to put the implied volatility spread in the stock-specific historical context when classifying a sizeable spread.

We use the following empirical procedure to identify a sizeable spread. For each underlying stock in a given day, we first match calls with puts on the basis of strike prices and maturities, and calculate the implied volatility spread as call implied volatilities in excess of put implied volatilities. In the presence of multiple pairs of matched call and put options for a given underlying stock, we average across all matched pairs for the same day.[12] Once the daily implied volatility spread series is available at the stock level, we calculate the stock-specific time-series average and standard deviation of the daily implied volatility spread before standardizing the implied volatility spread. A sizeable spread is identified when the absolute value of the standardized volatility spread exceeds a threshold value. In our empirical exercise, we employ both 1.96 and 2.58 as alternatives for the threshold value for the simple consideration that for a normally distributed random variable, 95 (99) percent of the area under the normal curve lies within 1.96 (2.58) standard deviations of the mean. [13]

For each announcement, we calculate the fraction of sizeable spreads as the ratio of total instances of sizeable spreads to the total number of matched call-put pairs. We then take the cross-sectional average fraction of sizeable spreads across each of the six five-day windows prior to the earnings announcement date. Table 2 reports the fraction of sizeable spreads using options with different maturities (30-day, 60-day and 90-day).

One striking result is that the fraction of sizeable spreads increases monotonically as we approach the date of earnings announcement. This pattern is robust regardless of whether we use the threshold value of 1.96 or 2.58 to classify sizeable spread. It also holds true in all three maturities with the strongest effect among options with maturities of 30 days or less. During the 30-day observation period prior to

[12] We also experiment with alternative weighting schemes such as weighting by open interest and weight by trading volume. The weighting schemes have little impact on the reported results.

[13] We thank an anonymous referee for pointing out the importance of the choice for the threshold value. We choose to use 1.96 and 2.58 as the threshold value since while we don't perform rigorous tests for the time series properties of implied volatility spread, these two values largely serve our intention to define the implied volatility deviations between calls and puts as small probability events.

the earnings announcement date, the fraction of sizeable spreads jumps from 11.38% at the earliest 5-day sub-period to 14.81% at the most recent 5-day sub-period (i.e., an increase of 30%) when the threshold value of 2.58 is used to define sizeable spread. The observation of more sizeable spreads among short-term options is quite understandable. Intuitively, informed traders would primarily trade short-term options since their private information about the upcoming announcements is often short-lived.

In untabulated results, we also test for the statistical significance of the difference between the fraction of sizeable spread in the five-day window immediately before the earnings announcement date and that in the other five more distant five-day windows. All these differences are reliably different from zero. Overall, the evidence presented in Table 2 lends support to Hypothesis 1a.

5.2. Implied volatility spread prior to extreme announcements

To separate speculative trading from informed trading, it is important to examine whether the sign and magnitude of the implied volatility spreads are consistent with those of subsequent earnings announcements. The speculative trading doesn't predict such a consistency because speculative trading lacks a directional view on future stock prices. In contrast, option orders from informed traders would induce a positive (or negative) implied volatility spreads, as their trades lead to more expensive call (or put) options, prior to positive (or negative) earnings announcements on the underlying securities. This effect should also be more pronounced among extreme announcements.

To test the above intuition corresponding to Hypothesis 1b, we first categorize earnings announcements based on abnormal announcement returns and then compute the fraction of sizeable implied volatility spreads. Announcements with positive abnormal returns are cast into five quintiles, with extremely positive returns in quintile 5 and returns closest to zero in quintile 1. Similarly, we define five quintiles among announcements with negative abnormal returns, with quintile 5 corresponding to extremely negative returns. The fraction of sizeable implied volatility spreads is tabulated for each of quintile using the threshold value of either 1.96 or 2.58 to determine whether the standardized implied volatility spread is sizeable for each given announcement. Table 3 reports only results using the threshold value of 2.58 since both threshold values lead to similar results. Panel A corresponds to positive announcements while Panel B negative.

Two patterns emerge. First, the fraction of sizeable implied volatility spread increases as we move closer to the date of announcement. This is the same pattern documented in Table 2 except that we are now witnessing its robustness across both positive and negative announcements and within each announcement return quintile. Second, there is a larger fraction of sizeable implied volatility spreads prior to more extreme announcements compared to announcements with close to zero abnormal announcement returns. This is true for each of the six five-day windows regardless of whether we examine positive announcements or negative announcements. Over the five days immediately before announcements, we observe a monotonic increase in the fraction of sizeable implied volatility spreads as the abnormal announcement returns get more extreme in terms of absolute magnitude. That prices of call (put) options are progressively more expensive prior to extremely positive (or negative) earnings announcements lends strong support for Hypothesis 1b.

5.3. Return predictability of pre-announcement implied volatility spread

While the fraction of sizeable implied volatility spreads we have analyzed in two previous subsections provides an interesting summary statistic over various scenarios and sheds light on the pattern of informed trading prior to earnings announcements, it is very descriptive in nature. To better understand the role of informed trading in the stock market response to earnings announcements, we construct a new variable to measure the change in implied volatility spread that is more conducive to a rigorous regression framework and examine its forecasting power for the announcement returns. The empirical evidence of the forecasting power would further reinforce the notion of options trading originating from informed traders before such announcements.

Instead of standardizing the implied volatility spread (i.e., comparing the spread to its time series average before scaling it by its standard deviation), we compute the cumulative abnormal implied volatility spread (*Vspread*) based on a reference window that is more refined than the full time series and thus better suited for an event study. To capture the abnormality of implied volatility spread immediately before the date of earnings announcement (denoted by t), we turn to the standard timing methodology in the literature. The four-day period immediately before the announcement (i.e., [t-5, t-2]) is defined as the pre-announcement window.[14] The 30-day period preceding the pre-announcement window is defined as the benchmark window. We subtract the average implied volatility spread in the benchmark window from the implied volatility spread in the pre-announcement window to calculate the abnormal implied volatility spread. The daily abnormal implied volatility is then cumulated over the pre-announcement window, arriving at the cumulative abnormal implied volatility spread, *Vspread.*

We estimate the following regression to detect the predictive power of the change in implied volatility spread on the announcement returns.

$$\begin{aligned} AnnRet_{t-1,t+1} = {} & \alpha_0 + \alpha_1 \cdot Vspread_{t-5,t-2} + \alpha_2 \cdot BM_{previous\ \text{fiscal qtr end}} + \alpha_3 \cdot IOR_{previous\ \text{qtr end}} \\ & + \alpha_4 \cdot Size_{previous\ \text{mth end}} + \alpha_5 \cdot Runup_{t-30,t-2} + \alpha_6 \cdot PastRet_{t-210,t-31} + \varepsilon \end{aligned}$$

[14] We define a four-day pre-announcement window because Amin and Lee (1997) document that the options market activity increases by over 10 percent in the four days before the EAD and that the direction of the pre-announcement options trading predicts subsequent earnings news.

The dependent variable is the announcement abnormal return capturing the stock market response. We include five independent variables to control for potential confounding factors. Book-to-market ratio (*BM*) is included to capture the value vs. glamour effect of stock returns. Institutional ownership ratio (*IOR*) is included since prior studies have documented that institutional ownership is important in explaining the stock price behavior around earnings announcements. *Size* is included because firms of different sizes have potentially different information structures. For instance, there normally exist better analyst coverages among larger firms and investors of large firms could be more attentive to earnings announcements. To account for return reversal or continuation, we include *PastRet*. As a proxy for information leakage, *Runup* is expected to have a negative relationship with *AnnRet*, and competes with our focal variable *Vspread*. Prior studies have shown that both the book-to-market ratio and institutional ownership affect the announcement returns. One main distinction is that options implied volatility is forward-looking by design and thus *Vspread* carries the forward-looking attribute. The pre-announcement options trading being informed would imply a positive and significant slope coefficient for *Vspread*.

Table 4 presents the estimates along with p-values from the ordinary OLS regression, the robust regression with heteroscedasticity-consistent standard errors, and the robust regression with standard errors clustered by firms. We immediately notice that across all three regression specifications, there is strong statistical evidence that the cumulative abnormal implied volatility spreads can forecast announcement returns in all three regressions. This finding complements the descriptive results in Table 3, lending additional support to Hypothesis 1b.

Several studies have documented supportive evidence that options trading volume, especially when the direction of options trading volume is signed using high-frequency or proprietary datasets, carries significant predictive power on future stock price movement both in regular times (Pan and Poteshman 2006) and around important corporate events (Cao et al. 2005). We carry another robustness check and examine whether the options trading volume has predictive power on the announcement returns within our context. Note that we have to use the unsigned options trading volume observed at the closing of each trading day because the OptionMetrics database does not provide intra-day option data on trades and quotes.

Options trading volume is defined as the number of contracts traded scaled by open interest. To calculate cumulative abnormal option volumes, we follow a procedure similar to the construction of cumulative abnormal implied volatility spread. That is, we first compute the daily abnormal option volume by subtracting the average options trading volume over the benchmark window [t-35, t-6] from the daily option volume in the pre-announcement window [t-5, t-2], and then cumulate it over the pre-announcement window to obtain the cumulative abnormal option volume (*OptVolume*). When replacing our main variable *Vspread* with *OptVolume* and re-run the regression tests, we find in untabulated results that none of the slope coefficient estimates for *OptVolume* exhibits statistical significance at the conventional levels.[15] It appears that our implied volatility spread measure is a more competitive proxy for informed trading than the unsigned options trading volume.

5.4. Implications of options trading on the stock market response

As discussed in Section 3.2, there are two potentially countervailing forces of pre-announcement options trading on the stock market response to subsequent earnings news. The information preemption hypothesis states that at least part of the new information will be preempted by informed traders in the options market. Hence, the stock market response to earnings surprises will be reduced when the announcements are actually made. The under-reaction correction hypothesis argues that since investors underreact to information released from earnings announcements and pre-earnings options trading helps attenuate the under-reaction, the stock market response can actually increase because of informed trading.

Apparently, these two hypotheses diverge on the implication of pre-announcement options trading activity on the subsequent stock market response. To capture the varying degree of options trading activities and examine how the stock market response varies with the pre-announcement options trading activity in the context of validating or refuting Hypothesis 2, we augment the widely used earnings response coefficient framework by incorporating an interaction term between *SUE* and *Vspread*. The inclusion of such an interaction term enables us to investigate how the earnings response coefficients are affected in the presence of varying degree of pre-announcement option volatility spread. Our regression design is specified as follows. [16]

$$AnnRet_{t-1,t+1} = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot SUE_t \cdot Vspread_{t-5,t-2} + \beta_4 \cdot BM_{previous\ \text{fiscal qtr end}} + \beta_5 \cdot IOR_{previous\ \text{qtr end}} + \beta_6 \cdot Size_{previous\ \text{mth end}} + \beta_7 \cdot Runup_{t-30,t-2} + \beta_8 \cdot PastRet_{t-210,t-31} + \varepsilon$$

The dependent variable is the announcement abnormal return. The slope coefficient estimates before *SUE* and its interaction term captures the stock market response in the presence of varying degree of volatility spread. We include five control variables to allow for other factors that may influence announcement returns. The motivation and predictions for the control variables are the same as discussed in Section 5.3. Our focus is on *SUE* and its interaction term. Hypothesis 2 states that

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[15] We also re-run the regression with independent variables including *Vspread*, *BM*, *IOR*, *PastRet*, *Size*, and *Runup* as well as *OptVolume*. The inclusion of *OptVolume* has a negligible effect on the magnitude and no effect on the statistical significance of the estimates on all other variables, with an insignificant estimated coefficient for *OptVolume*.

[16] *Vspread* by itself is included in the regression to examine the predictive power of implied volatility spread. We thank an anonymous referee for pointing this out.

significantly negative estimates before interaction terms support the information preemption hypothesis whereas significantly positive estimates support the under-reaction correction hypothesis.

Table 5 presents the estimated coefficients along with p-values from the OLS regression, the regression with the heteroscedasticity-consistent standard errors, and the regression with the standard errors clustered by firms. Most of the control variables carry slope coefficient estimates that are statistically significant at conventional levels. For instance, larger firms, firms with high book-to-market values, and firms that have experience greater pre-earnings stock price run-up are associated with smaller stock market response, whereas firms with higher institutional ownership ratios are associated with larger stock market response.

For *SUE*, the estimated coefficient is 0.22 and reliably different from zero. Thus, the greater the information shock, the stronger the stock market reaction. In addition, *Vspread* carries a positive and significant estimate of 0.02, which is consistent with the results in Table 4. More importantly, the slope coefficient estimate of 0.42 for the interaction term between *SUE* and *Vspread* is statistically significant at 1 percent level even when *Vspread* is included in the regression. This is clear evidence of data supporting the under-reaction correction hypothesis rather than the information pre-emption hypothesis.

5.5. The role of options trading volume

To test Hypothesis 3, we propose the use of cumulative abnormal options trading volume *OptVolume*. This is similar to Barber and Odean (2008) who use a stock's abnormal daily trading volume to capture the change in investors' attention to the stock. As a first pass at testing Hypothesis 3, we slice the sample into two subsamples based on the *OptVolume* immediately before earnings announcement dates, announcements with the top 50 percent of *OptVolume* and announcements with the bottom 50 percent of *OptVolume*. Table 6 presents the estimated coefficients of the same regression design for two subsamples, along with p-values calculated from the OLS, the robust regression with the heteroscedasticity-consistent standard errors, and robust regression with firm clustered standard errors.

The results in Table 5 appear to hold well for two subsamples in Table 6. The focal variables – *SUE* and its interaction terms with *Vspread* – carry the same sign as in the full sample and remain statistically significant at the conventional levels. Between the two subsamples, announcements with high *OptVolume* have much larger estimated coefficients before the focal variables and stronger statistical significance, compared to the subsample of announcements with low *OptVolume*. The much stronger stock market response to earnings announcements preceded by higher options trading volume lends empirical support to Hypothesis 3.

To further substantiate the stronger stock market response among announcements with high pre-announcement options trading volumes, we carry out an additional empirical test to examine the confounding effect of pre-earnings option trading volume. Specifically, we estimate the following regression equation:

$$\begin{aligned} AnnRet_{t-1,t+1} &= \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot OptVolume_{t-5,t-2} + \beta_4 \cdot SUE_t \cdot Vspread_{t-5,t-2} \\ &+ \beta_5 \cdot SUE_t \cdot OptVolume_{t-5,t-2} + \beta_6 \cdot SUE_t \cdot Vspread_{t-5,t-2} \cdot OptVolume_{t-5,t-2} \\ &+ \beta_7 \cdot BM_{previous \text{ fiscal qtr end}} + \beta_8 \cdot IOR_{previous \text{ qtr end}} + \beta_9 \cdot Size_{previous \text{ mth end}} + \beta_{10} \cdot Runup_{t-30,t-2} \\ &+ \beta_{11} \cdot PastRet_{t-210,t-31} + \varepsilon \end{aligned}$$

We interact *SUE* with not only *Vspread* but also *OptVolume* to examine whether the addition of the pre-earnings option trading volume changes or crowds out the implied volatility spread effect. Furthermore, we add an interaction term among *SUE*, *Vspread* and *OptVolume*. The estimation results are reported in Table 7. Our focal variables are *SUE* and its interaction terms with *Vspread* as well as *OptVolume*.

In Table 7, the estimated coefficient for *SUE* is positive and statistically significant using the three alternative estimation methods. Moreover, we notice that the interaction term between *SUE* and *OptVolume* is negative and insignificant. This is not surprising given that the option trading volume is unsigned. In comparison, the estimated coefficient for the interaction term between *SUE* and *Vspread* is also positive and strongly significant in the presence of *OptVolume*. This effect seems to be more pronounced among announcements with higher pre-earnings option volume, as evidenced by the positive and significant slope coefficient estimate before *SUE*, *Vspread* and *OptVolume*. Overall, the results in Table 6 and 7 speak to the important implications of options trading volume on the subsequent stock market response to earnings announcements.

5.6. Implications of options trading on post-earnings announcement drift

To the extent that pre-announcement options trading alleviates stock market under-reaction to earnings announcements as the under-reaction correction hypothesis suggests, we should expect smaller post earnings announcement drift among announcements that have witnessed higher options trading activity. We again use the cumulative abnormal implied volatility spread to capture pre-announcement option market trading activity and focus on the interaction term between *SUE* and *Vspread*.

To test Hypothesis 4, we estimate the following regression equation.

$$PEAD_{t+2,t+91} = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot OptVolume_{t-5,t-2} + \beta_4 \cdot SUE_t \cdot Vspread_{t-5,t-2}$$
$$+ \beta_5 \cdot SUE_t \cdot OptVolume_{t-5,t-2} + \beta_6 \cdot SUE_t \cdot Vspread_{t-5,t-2} \cdot OptVolume_{t-5,t-2}$$
$$+ \beta_7 \cdot BM_{previous\ \text{fiscal qtr end}} + \beta_8 \cdot IOR_{previous\ \text{qtr end}} + \beta_9 \cdot Size_{previous\ \text{mth end}} + \beta_{10} \cdot Runup_{t-30,t-2}$$
$$+ \beta_{11} \cdot PastRet_{t-210,t-31} + \varepsilon$$

The dependent variable – post-earnings announcement drift (PEAD) – is defined as the abnormal daily stock returns cumulated over the time window [t+2, t+91], where t denotes the earnings announcement date.[17] The explanatory variables include similar control variables, *BM*, *IOR*, *Size*, *Runup*, and *PastRet*. Our focal variables are *SUE* and its interaction terms with *Vspread* and *OptVolume*. The under-reaction correction hypothesis predicts a weaker post-earnings announcement drift, so negative estimates for *SUE* and its interaction terms will amount to supporting evidence.

The estimation results are presented in Table 8. Note that the slope coefficient estimate before *SUE* is positive and insignificant. Thus, we only find a weak post-earnings announcement return drift. The estimates for the interaction terms between *SUE* and *Vspread* is positive but statistically indistinguishable from zero in the two robust regression specifications. We indeed notice that the parameter estimate before the interaction term among *SUE*, *Vspread*, and *OptVolume* is negative but insignificant. We think it could be attributed to the fact that the post-earnings announcement drift test typically has lower statistical power, as pointed out by Mendenhall and Fehrs (1999).

6. Robustness Check

We perform two sets of robustness check to make sure that our empirical results are not affected by the alternative empirical methodologies and designs.

6.1. Alternative specifications for abnormal returns

Our first set of robustness check pertain to alternative specification of abnormal returns. In Section 3.2 and the subsequent analysis, we calculate the abnormal return using the parameter estimates from a market model estimated using return data over the time window [t-210, t-31]. To examine whether our results are robust to alternative ways of calculating abnormal returns, we calculate abnormal returns as the raw daily return minus the returns on portfolios of firms with similar size (size decile portfolios). This is similar to Livnat and Mendenhall (2006). The size decile portfolio returns are extracted from the Wharton Research Data Service portal from the University of Pennsylvania.

Using this alternative abnormal return specification, we re-run all the empirical tests. We find that this alternative specification of abnormal returns has little impact on the results reported in Table 4 through

[17] We also experimented with a 60-day window to measure the post earnings announcement drift and found qualitatively similar results.

Table 8. To conserve space, we choose to report the estimation results for Table 5 using this abnormal return specification since Table 5 establishes our core empirical results.

Table 9 reports the results of this robustness check. As we can see clearly, both *Vspread* and *SUE*Vspread* carry positive and statistically significant coefficient estimates. The magnitude of these estimates are also comparable to those reported in Table 5.

6.2. Alternative empirical design for *Vspread*

The cumulative abnormal implied volatility spread, *Vspread*, is another key variable for our empirical analysis. Our second set of robustness check is related to an alternative empirical design of this variable. The summary statistics in Table 1 shows that there are extreme values of *Vspread*. To mitigate the potential effects of outliers and facilitate the interpretation of the slope coefficient estimates, we construct dummy variables for *Vspread*. More specifically, all announcements are sorted into two groups using the 50th percentile point of *Vspread*. The bottom group contains one half of announcements with low cumulative abnormal implied volatility spread, whereas the top group includes the other half of announcements with high cumulative abnormal implied volatility spread. *Vspreadidx* takes the value of 1 for the top group and zero otherwise.

Using these dummy variables, we revise and re-estimate all the regression equations in Table 4 through Table 8. Again we find that our empirical results survive the alternative empirical design for *Vspread*. To conserve space, we choose to report the robustness check result for Table 5. The following revised regression equation is estimated:

$$AnnRet = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspreadidx + \beta_3 \cdot SUE_t \cdot Vspreadidx + \beta_4 \cdot BM + \beta_5 \cdot IOR + \beta_6 \cdot Size + \beta_7 \cdot Runup + \beta_8 \cdot PastRet + \varepsilon$$

Table 10 presents the estimate results. As we can see, both *Vspreadidx* and the interaction term *SUE*Vspreadidx* show up as positive and statistically significant. Moving from the bottom group of *Vspread* to the top group increases the earnings response coefficient from 0.161 to 0.241, an increase of almost 50 percent. Overall, results from using this dummy variable design are consistent with those in Table 5.

7. Conclusions

In this paper, we document an interesting time-series pattern of steadily increasing implied volatility spread in the month leading up to earnings announcements. When we slice the month into six five-day intervals, there is a monotonic increase in fraction of sizeable implied volatility spreads as we get closer to the date of announcement. This pattern is robust to options with different maturities as well as alternative thresholds for sizeable spreads. When slicing the sample of announcements into those with positive announcement returns and those with negative announcement returns, we continue to observe the monotonicity across both subsamples. When announcements are further stratified into five quintiles based on the magnitude of announcement returns, the monotonicity holds in each quintile with the strongest effect among the most extreme quintiles. The steady build-up of pre-announcement volatility spreads, coupled with the predictive power of the cumulative abnormal implied volatility spreads on subsequent announcement returns, suggests that informed traders are the driving force behind the option market activities prior to earnings announcements.

The novelty of this paper is that we advocate the use of implied volatility spread constructed from the options market to investigate the stock market response to earnings announcements. Using volatility spread as a proxy for informed trading helps us get around the data availability issue (proprietary options data are not publicly available) and avoid potentially problematic inferences from using unsigned options trading volume. This proxy also makes it feasible for us to examine varying degrees of options trading activities, shedding new lights on the economic implications of options trading above and beyond the binary outcomes of options listing status. Given the increased prevalence of options trading activities, the use of implied volatility spread in the earnings context is an important extension and contribution to the literature.

Our most important finding is that earnings response coefficients turn out to be stronger among announcements with higher implied volatility spread during the pre-announcement window. This is in sharp contrast to some of the earlier findings supporting the information preemption hypothesis (Skinner (1990), Ho (1993), Ho et al. (1995)). Under this hypothesis, the pre-announcement option trades could have revealed much of the market-moving information behind earnings announcements, so more active option trades would precede a weaker response to earnings news.

Our finding of a stronger response is nevertheless consistent with Mendehall and Fehrs (1999) who also find increased earnings response coefficients. Our paper differs from theirs in that we hypothesize the existence of an under-reaction correction effect of pre-earnings options trading on stock market response in the context of stock market under-reaction at announcement times and post-earnings announcement drift. We perform further robustness tests for this under-reaction correction hypothesis and document strong supportive evidence that pre-earnings options trading helps alleviate stock market under-reaction to earnings announcements and make the stock market response more complete.

While the exact mechanisms through which the stock market under-reaction is reduced remain unclear, we propose several candidate channels, namely, the transaction cost channel, the price discovery channel and the investor attention channel. Due to the lack of transaction-level data for option trades, we cannot test for these channels directly in this paper. Future research is needed to illustrate how the stock market under-reaction is mitigated because of pre-earnings options trading and how closer the stock market response is to a complete response (i.e., the absence of stock market under-reaction).

We also demonstrate evidence of a reduction in post earnings announcement drift among announcements with extreme earnings surprises. The interaction terms between earnings surprise and dummy variables for pre-announcement option trade are indistinguishable from zero, however. Further work is needed in the future to better understand the implications of options trading on post-earnings announcement drift.

REFERENCES

Admati Anat and Paul Pfleiderer, 1988, A theory of intraday patterns: Volume and price variability, *Review of Financial Studies*, Vol. 1, No. 1, 3–40

Alldredge Dallin, Benjamin Blau and Michael Pinegar, 2011, Information or speculation: what motivates pre-earnings announcement option activity? Manuscript of University of Tennessee in Knoxville

Amin Kaushik and Charles Lee, 1997, Option trading, price discovery, and earnings news dissemination, *Contemporary Accounting Research*, Vol. 14, Issue 2, 153-192

Anthony Joseph, 1988, The interrelation of stock and options market trading-volume data, *Journal of Finance*, Vol. 43, Issue 4, 949-964

Atiase, Rowland, 1985, Pre-disclosure information, firm capitalization, and security price behavior around earnings announcements, *Journal of Accounting Research*, Vol. 23, No. 1, 21–36

Atiase Rowland, 1994, Trading volume reactions to annual accounting earnings announcements: the incremental role of pre-disclosure information asymmetry, *Journal of Accounting and Economics*, Vol. 17, Issue 3, 309-329

Bagnoli, M., Kross, W. and Watts, S. G., The information in management's expected earnings report date: a day late, a penny short, *Journal of Accounting Research*, Vol. 40 no. 5, December, 2002, pp. 1275–96

Bali Turan, Armen Hovakimian, 2009, Volatility spreads and expected stock returns, *Management Science*, Vol. 55, No. 11, 1797-1812

Ball Ray, and Philip Brown, 1968, An empirical evaluation of accounting income numbers, *Journal of Accounting Research* 6, 159-178

Banerjee Prithviraj, James Doran, David Peterson, 2007, Implied volatility and future portfolio returns, *Journal of Banking and Finance*, 3183-3199

Barber Brad and Terrance Odean, 2008, All that glitters: the effect of attention and news on buying behavior of individual and institutional investors, *Review of Financial Studies*, Vol. 21, No. 2, 785-818

Battalio Robert, and Paul Schultz, 2006, Options and the bubble, *Journal of Finance*, Vol. 61, No. 5, 2071-2102

Bernard Victor, and Jacob Thomas, 1989, Post-earnings-announcement drift: delayed price responses or risk premium, *Journal of Accounting Research* 27 (Suppl.), 1-36

Bernard Victor, and Jacob Thomas, 1990, Evidence that stock prices do not fully reflect the implications of current earnings for future earnings, *Journal of Accounting and Economics*, Vol. 13, 305-340

Bhushan, Ravi, 1994, An informational efficiency perspective on the post-earnings announcement drift, *Journal of Accounting and Economics*, Vol. 18, 45-65

Black Fisher, 1975, Fact and fantasy in the use of options, *Financial Analysts Journal* 31, 36-41

Black Fischer, and Myron Scholes, 1973, The pricing of options and corporate liabilities, *Journal of Political Economy*, Vol. 81, No. 3, 637-654.

Cao Charles, Zhiwu Chen, and John Griffin, 2005, Informational content of option volume prior to takeover, *Journal of Business* 78, 1073-1109

Chan Howard, Robert Faff and Alan Ramsay, Firm size and the information content of annual earnings announcements: Australian evidence, *Journal of Business Finance and Accounting*, Vol. 32, Issue 1-2, 211-253

Chakravarty Sugato, Huseyin Gulen, and Stewart Mayhew, 2004, Informed trading in the stock and the options markets, *Journal of Finance*, 59(3), 1235-1258

Chordia Tarun and Swaminathan Bhaskaran, 2000, Trading volume and cross-autocorrelations in stock returns, *Journal of Finance*, Vol. 55, No. 2, 913-935

Chordia Tarun, Amit Goyal, Ronnie Sadka and Lakshmanan Shivakumar, 2009, Liquidity and the post-earnings-announcement drift, *Financial Analysts Journal*, 65, 18-32

Collins Daniel, Kothari S. P. and Rayburn Judy Dawson, 1987, Firm size and the information content of prices with respect to earnings, *Journal of Accounting and Economics*, Vol. 9, No. 2, 111–138

Cremers Martijin, Weinbaum, David, 2010, Deviations from Put-Call Parity and Stock Return Predictability, *Journal of Financial and Quantitative Analysis*, Vol. 45 No. 2, 335-367

Damodaran Aswath, 1991, The effects of option listing on the underlying stocks' return processes, Journal of Banking & Finance, Vol. 15, Issue 3, 647-664

Della Vigna Stefano and Joshua Pollet, 2009, Investor inattention and Friday earnings announcements, *Journal of Finance*, Vol. 64, No. 2, 709-749

Dempsey, Stephen, 1989, Pre-disclosure Information search incentives, analyst following, and earnings announcement price response, *The Accounting Review*, Vol. 64, No. 4, 748–757

Donders Monique, Roy Kouwenberg and Ton Vorst, 2000, Options and earnings announcements: an empirical study of volatility, trading volume, open interest, and liquidity, *European Financial Management*, Vol. 6, Issue 2, 149-171

Dontoh, A., Ronen, J., and Sarath, B., 2003, On the rationality of the post-announcement drift, *Review of Accounting Studies* 8, 69-104

Doran James and Kevin Krieger, 2010, Implications for asset returns in the implied volatility skew, *Financial Analysts Journal*, Vol. 66, No. 1, 65-76

Easley David, Maureen O'Hara and P.S. Srinivas, 1998, Option volume and stock prices: evidence on where informed traders trade, *Journal of Finance*, Vol. 53, Issue 2, 431-465

Faff Robert and David Hillier, 2005, Complete markets, informed trading and equity option introductions, *Journal of Banking and Finance*, Vol. 29, No. 6, 1359-1384

Fedenia Mark, and Theoharry Grammatikos, 1992, Options trading and the bid-ask spread of the underlying stock, *Journal of Business* Vol. 65, No. 3, 335-351

Foster, F. D. and Viswanathan, S., 1994, Strategic trading with asymmetrically informed traders and long-lived information, *Journal of Financial and Quantitative Analysis*, Vol. 29. No. 4, 499–518

Foster, F. D. and Viswanathan, S., 1996, Strategic trading when agents forecast the forecasts of others, *Journal of Finance*, Vol. 51. No. 4, 1437–1478

Freeman, Robert, 1987, The association between accounting earnings and security returns for large and small firms, *Journal of Accounting and Economics*, Vol. 9, No. 2, 195–228

Gervais Simon, Ron Kaniel and Dan Mingelgrin, 2001, The high-volume return premium, *Journal of Finance*, Vol. 56, No. 3, 877-919

Govindaraj Suresh, Sangsang Liu and Joshua Livnat, 2012, The post earnings announcement drift and option traders, working paper, Rutgers University

Grant, Edward, 1980, Market implications of differential amounts of interim information, *Journal of Accounting Research*, Vol. 18, No. 1, 255–268

Hirshleifer David, Sonya Seongyeon Lim, and Siewhong, Teoh, 2009, Driven to distraction: extraneous events and under-reaction to earnings news, *Journal of Finance*, Vol. 64, Issue 5, 2289-2325

Holden, C. W. and Subrahmanyam, A., 1992, Long-lived private information and imperfect competition, *Journal of Finance*, Vol. 47. No. 1, 247–270

Hou Kewei, Lin Peng, and Wei Xiong, 2009, A tale of two anomalies: the implication of investor attention for price and earnings momentum, working paper, Ohio State University

Ho Li-Chin, 1993, Option trading and the relation between price and earnings: a cross-sectional analysis, *The Accounting Review*, Vol. 68, No. 2, 368-384

Ho Li-Chin, John Hassell and Steve Swidler, 1995, An empirical examination of the dispersion and accuracy of analyst forecasts surrounding option listing, *Review of Financial Economics*, Vol. 4, Issue 2, 171-185

Huddart, S., Ke, B. and Shi, C., 2001, Jeopardy, non-public information, and insider trading around SEC 10-K and 10-Q filings, *Journal of Accounting and Economics*, Vol. 43. No. 1, 3–36

Jennings Robert and Laura Starks, 1986, Earnings announcements, stock price adjustment, and the existence of option markets, *Journal of Finance*, 41(1), 107-125

Jin Wen, Josha Livnat and Yuan Zhang, 2012, Option prices leading equity prices: do option traders have an information advantage? *Journal of Accounting Research*, Vol. 50, Issue 2, 401-432

Johnson Travis, and Eric So, 2012, The option to stock volume ratio and future returns, *Journal of Financial Economics*, 106(2): 262-286

Kahneman, Daniel, 1973, Attention and Effort, Englewood Cliffs, NJ: Prentice-Hall

Konchitchki Yaniv, Xiaoxia Lou, Gil Sadka, and Ronnie Sadka, 2012, Underreaction or risk? Expected earnings and the post-earnings-announcement drift, working paper, University of California at Berkeley

Kumar Raman, Atulya Sarin and Kuldeep Shastri, 1998, The impact of options trading on the market quality of the underlying security: an empirical analysis, *Journal of Finance*, April, Vol. 53, Issue 2, 717-732

Kyle Albert, 1985, Continuous auctions and insider trading, *Econometrica*, Vol. 53, No. 6, 1315-1335

Kyle, A. S., 1989, Informed speculation with imperfect competition, *Review of Economic Studies*, Vol. 56. No. 3, 317–355

Lakonishok Joseph, Inmoo Lee, Neil Pearson and Allen Poteshman, 2007, Option market activity, *Review of Financial Studies*, Vol. 20, No. 3, 813-857

Lei Qin and Xuewu Wang, 2014, Time-Varying liquidity trading, private Information and insider trading, *European Financial Management*, Vol. 20, Issue 2, 321-351

Levitt, Arthur, 1998, The numbers game, speech delivered at the NUY Center for Law and Business, New York, September 28, 1998

Livnat Joshua and Mendenhall Richard, 2006, Comparing the post-earnings announcement drift for surprised calculated from analyst and time series forecasts, *Journal of Accounting Research*, 44 (1), 177-205

Lo Andrew and Wang Jiang, 2000, Trading volume: definitions, data analysis, and implications of portfolio theory, *Review of Financial Studies*, Vol. 13, No. 2, 257-300

Lobo Gerald and Mahmoud Amal, 1989, Relationship between differential amounts of prior information and security return variability, *Journal of Accounting Research*, Vol. 27, No. 1, 116–134

Mendenhall Richard, 2004, Arbitrage risk and the post earnings-announcement drift, *Journal of Business*, 77 (4), 875-894

Mendenhall Richard and Donald Fehrs, 1999, Option listing and the stock-price response to earnings announcements, *Journal of Accounting and Economics*, Vol. 27, Issue 1, 57-87

Ng Jeffrey, Tjomme Rusticus, and Rodrigo Verdi, 2008, Implications of transaction costs for the post-earnings-announcement drift, *Journal of Accounting Research* 46, 661-696

Ni Sophie, Jun Pan and Allen Poteshman, 2008, Volatility information trading in the option market, *Journal of Finance*, 63(3), 1059-1091

Ofek, Eli, Matthew Richardson, and Robert Whitelaw, 2004, Limited arbitrage and short sales restrictions: evidence from the options markets, *Journal of Financial Economics*, Vol. 74, No. 2, 305-342

Pan Jun and Allen Poteshman, 2006, The information in option volume for future stock prices, *Review of Financial Studies*, Vol. 19, Issue 3, 871-908

Peng Lin, 2005, Learning with information capacity constraints, *Journal of Financial and Quantitative Analysis* 40, 307–330

Peng Lin and Wei Xiong, 2006, Investor attention, overconfidence and category learning, *Journal of Financial Economics* 80, 563-602

Roll Richard, Educardo Schwartz, and Avanidhar Subrahmanyam, 2010, O/S: the relative trading activity in options and stock, *Journal of Financial Economics*, 96(1), 1-17

Sadka Gil, and Ronnie Sadka, 2009, Predictability and the earnings-returns relation, *Journal of Financial Economics* 94, 87-106

Sadka Ronnie, 2006, Momentum and the post-earnings-announcement drift anomalies: the role of liquidity risk, *Journal of Financial Economics* 80, 309-349

Shores, D., 1990, The association between interim information and security returns surrounding earnings announcements, *Journal of Accounting Research*, Vol. 28, No. 1, 164–181

Skinner Douglas, 1990, Options markets and the information content of accounting earnings releases, *Journal of Accounting and Economics*, Vol. 13, Issue 3, 191-211

Teets Walter, and Charles Wasley, 1996, Estimating earnings response coefficients: pooled versus firm-specific models, *Journal of Accounting and Economics*, Vol. 21, Issue 3, 279-295

Turong Cameron, 2012, Options trading and the extent that stock prices lead future earnings information, *Journal of Business Finance and Accounting*, Vol. 39, Issue 7-8, 960-996

Turong Cameron, and Charles Corrado, 2014, Options trading volume and stock price response to earnings announcements, *Review of Accounting Studies*, Vol. 19, Issue 1, 161-209

Turong Cameron, Charles Corrado and Yangyang Chen, 2012, The options market response to accounting earnings announcements, *Journal of International Financial Markets, Institutions and Money*, Vol. 22, Issue 3, 423-450

Xing Yuhang, Xiaoyan Zhang, and Rui Zhao, 2010, What does the individual option volatility smirk tell us about future equity returns? *Journal of Financial and Quantitative Analysis*, Vol. 45, No. 3, 641-662

Table 1: Summary Statistics of Core and Control Variables

This table presents the summary statistics of the variables used in the empirical analysis. The announcement return (*AnnRet*) is defined as abnormal returns cumulated over the event window [t-1, t+1], where t denotes the earnings announcement date. A market model is estimated over the estimation window [t-210, t-31] to obtain the alpha and beta parameter estimates. The daily abnormal return series is computed as the daily stock return in excess of the predicted daily return using the estimate coefficients from the market model. The standardized unexpected earnings (*SUE*) is calculated as actual reported earnings per share minus median analyst forecast within 90 days prior to earnings announcement date, deflated by the closing price in the previous quarter. Size is the market capitalization measured as natural log of shares outstanding multiplied by closing price. The pre-announcement stock price run-up (*Runup*) is defined as the abnormal stock returns cumulated over [t − 30, t − 2]. Past stock return (*PastRet*) is defined as the buy-and-hold stock return cumulated over [t − 210, t − 31]. *Vspread* is abnormal implied volatility spread cumulated over the event window [t-5, t-2]. Implied volatility spread is defined as the difference between the call and put implied volatility, where call options are matched with put options based on the strike prices and maturities. Implied volatility spread is averaged across all matched pairs for each underlying stock. The abnormal implied volatility spread for each day in the event window is calculated by subtracting the average volatility spread over the benchmark window [t-35, t-6] from the daily volatility spread and then cumulated to obtain the cumulative abnormal implied volatility spread. *BM* is the book to market value ratio. *IOR* is the institutional ownership defined as the institutional holdings divided by the shares outstanding. *OptVolume* is the abnormal option volume cumulated over the event window [t-5, t-2]. Daily abnormal option volume is calculated by subtracting the average options trading volume over the benchmark window [t-35, t-6] from the daily option volume in the event window [t-5, t-2], which is then cumulated over the pre-announcement window to obtain the cumulative abnormal option volume.

Variable	No. of Obs.	Min.	25th	50th	75th	Max.	Std.
AnnRet	128,438	-0.969	-0.038	0.002	0.045	1.357	0.090
SUE	128,438	-4.036	0.000	0.000	0.002	1.599	0.035
Size	128,438	8.835	13.225	14.196	15.307	20.424	1.559
Runup	128,438	-1.635	-0.054	0.001	0.056	2.967	0.125
PastRet	128,438	-0.960	-0.129	0.052	0.235	30.923	0.477
Vspread	128,438	-5.092	-0.024	0.001	0.026	2.771	0.078
BM	128,438	-101.736	0.255	0.445	0.721	24.002	0.725
IOR	128,438	0.000	0.545	0.710	0.842	6.656	0.232
OptVolume	128,438	-141.881	-0.040	0.009	0.092	471.324	1.826

Table 2: Unconditional Fraction of Sizeable Implied Volatility Spread

This table presents the fraction of sizeable implied volatility spread during the one-month period leading up to the earnings announcement date. The pre-announcement one-month period is divided into six five-day windows. A sizeable implied volatility spread is detected when the absolute value of implied volatility spread deviates from its time series average by a threshold number of standard deviations. For each announcement, the fraction of sizeable implied volatility spread is defined as total instances of sizeable implied volatility spread divided by the total number of matched call-put pairs. A cross-sectional average fraction of sizeable implied volatility spread is then computed across all announcements for each five-day window. The first column reports the threshold value used to define sizeable implied volatility spread, either 1.96 or 2.58. The second column documents the maturity of options used. The last six columns provide the cross-sectional average fractions of sizeable implied volatility spread corresponding to the six five-day windows prior to the earnings announcement date.

Std. Dev.	Maturity	[t-30,t-26]	[t-25,t-20]	[t-20,t-16]	[t-15,t-11]	[t-10,t-6]	[t-5,t-1]
1.96	90-day	13.35%	13.61%	13.80%	14.01%	14.34%	14.92%
	60-day	13.74%	14.08%	14.36%	14.53%	14.93%	15.70%
	30-day	17.69%	18.79%	19.45%	19.71%	20.60%	21.77%
2.58	90-day	8.18%	8.39%	8.53%	8.72%	8.93%	9.40%
	60-day	8.46%	8.71%	8.91%	9.08%	9.34%	9.96%
	30-day	11.38%	12.23%	12.66%	13.01%	13.73%	14.81%

Table 3: Conditional Fraction of Sizeable Implied Volatility Spread

This table presents the fraction of sizeable implied volatility spread conditional on announcement returns. The methodology to calculate the fraction of sizeable implied volatility spread is similar to the one outlined in Table 2. The whole sample is sliced into two subsamples, announcements with positive announcement returns and announcements with negative announcement returns. For each subsample, all announcements are sorted into five quintiles based on the absolute magnitude of announcement returns. Quintile 1 contains announcements with abnormal announcement returns closest to zero and Quintile 5 most extreme abnormal announcement returns (either positive or negative). The fraction of sizeable implied volatility spread is then calculated across each quintile. For brevity reasons, we only report the fraction of sizeable volatility spread calculated from options with a maturity of 30 days or less with a standard deviation threshold of 2.58. Panel A and B report the fraction of sizeable implied volatility spread conditional on positive and negative announcement returns, respectively.

Panel A: Conditional on Positive Announcement Returns						
Quintile	[t-30,t-26]	[t-25,t-21]	[t-20,t-16]	[t-15,t-11]	[t-10,t-6]	[t-5,t-1]
1	5.28%	5.49%	5.70%	5.67%	6.41%	7.07%
2	5.23%	5.36%	5.86%	5.78%	6.35%	6.90%
3	5.35%	5.71%	5.63%	5.79%	6.41%	7.19%
4	5.56%	5.78%	6.19%	6.01%	6.82%	7.43%
5	5.97%	6.69%	6.81%	6.80%	7.45%	8.60%
Panel B: Conditional on Negative Announcement Returns						
Quintile	[t-30,t-26]	[t-25,t-21]	[t-20,t-16]	[t-15,t-11]	[t-10,t-6]	[t-5,t-1]
1	6.11%	6.59%	6.25%	6.45%	6.53%	6.92%
2	5.81%	6.32%	6.49%	6.78%	6.42%	6.98%
3	6.06%	6.73%	6.61%	6.80%	6.73%	7.29%
4	6.09%	6.27%	6.77%	7.40%	7.63%	8.06%
5	6.76%	7.20%	7.75%	8.15%	8.46%	8.66%

Table 4: Implied Volatility Spread Predicting Announcement Returns

This table examines the predictive power of implied volatility spread on announcement returns. The regression equation is specified as follows:

$$AnnRet_{t-1,t+1} = \alpha_0 + \alpha_1 \cdot Vspread_{t-5,t-2} + \alpha_2 \cdot BM_{previous\ \text{fiscal qtr end}} + \alpha_3 \cdot IOR_{previous\ \text{qtr end}} + \alpha_4 \cdot Size_{previous\ \text{mth end}} + \alpha_5 \cdot Runup_{t-30,t-2} + \alpha_6 \cdot PastRet_{t-210,t-31} + \varepsilon$$

AnnRet is the announcement return; *Vspread* is the cumulative abnormal implied volatility spread; *BM* is the book to market ratio; *IOR* is the institutional ownership; Size is the firm size; *Runup* is the pre-announcement stock price run-up; *PastRet* is the past stock return. The methodologies for constructing these variables are as outlined in Table 1. The regression equation is estimated using three alternative methods: ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0050	0.0347	0.0707	0.1196
Vspread	**0.0139**	**<.0001**	**0.0016**	**0.0015**
BM	-0.0046	<.0001	0.0002	0.0061
IOR	0.0200	<.0001	<.0001	<.0001
Size	-0.0003	0.0633	0.0611	0.0917
Runup	-0.0168	<.0001	<.0001	<.0001
PastRet	0.0000	0.9296	0.9568	0.9569

Table 5: Implied Volatility Spread and Stock Market Response to EAs: Whole Sample Analysis

This table examines the implications of pre-announcement implied volatility spread on the stock market response to earnings announcements. The regression equation is specified as follows:

$$AnnRet_{t-1,t+1} = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot SUE_t \cdot Vspread_{t-5,t-2} + \beta_4 \cdot BM_{previous\ \text{fiscal qtr end}}$$
$$+ \beta_5 \cdot IOR_{previous\ \text{qtr end}} + \beta_6 \cdot Size_{previous\ \text{mth end}} + \beta_7 \cdot Runup_{t-30,t-2} + \beta_8 \cdot PastRet_{t-210,t-31} + \varepsilon$$

AnnRet is the announcement return; *SUE* is the standardized unexpected earnings; *Vspread* is the cumulative abnormal implied volatility spread; *BM* is the book to market ratio; *IOR* is the institutional ownership; Size is the firm size; *Runup* is the pre-announcement stock price run-up; *PastRet* is the past stock return. The methodologies for constructing these variables are as outlined in Table 1. The regression equation is estimated using three alternative methods: the ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0028	0.2366	0.3075	0.3743
SUE	0.2158	<.0001	<.0001	<.0001
Vspread	0.0160	<.0001	0.0003	0.0002
SUE* Vspread	**0.4192**	**<.0001**	**0.0001**	**0.0002**
BM	-0.0044	<.0001	0.0001	0.0046
IOR	0.0196	<.0001	<.0001	<.0001
Size	-0.0004	0.0074	0.0068	0.0145
Runup	-0.0181	<.0001	<.0001	<.0001
PastRet	-0.0003	0.6223	0.7632	0.765

Table 6: The Role of Options trading Volume on Stock Market Response: Subsample Analysis

This table performs the subsample analysis of the implications of volatility spread on the stock market response to earnings announcements, utilizing the following regression specification.

$$AnnRet_{t-1,t+1} = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot SUE_t \cdot Vspread_{t-5,t-2} + \beta_4 \cdot BM_{previous\ \text{fiscal qtr end}}$$
$$+ \beta_5 \cdot IOR_{previous\ \text{qtr end}} + \beta_6 \cdot Size_{previous\ \text{mth end}} + \beta_7 \cdot Runup_{t-30,t-2} + \beta_8 \cdot PastRet_{t-210,t-31} + \varepsilon$$

All variables are as constructed in Table 1. For each announcement we first calculate the daily abnormal option volume by subtracting the average options trading volume over the benchmark window [t-35, t-6] from the daily option volume in the event window [t-5, t-2]. The daily abnormal option volume is then cumulated over the event window to obtain the cumulative abnormal option volume *OptVolume*. The whole sample is then sliced into two subsamples based on the median *OptVolume*. The regression equation is then estimated for each subsample. Panel A and Panel B separately report regression results from using announcements with the top and bottom half *OptVolume*. The parameter estimates are present in Column 2. The last three columns present the P-values for the parameter estimates from the OLS regression, robust regression with heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors in the last three columns.

Panel A: Using the top 50 percent *OptVolume*

Variable	Parameter Estimate	P Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	0.0094	0.0074	0.0158	0.0223
SUE	0.2763	<.0001	<.0001	<.0001
Vspread	0.0137	0.0079	0.0598	0.0564
SUE* Vspread	**0.6044**	**<.0001**	**0.0013**	**0.0013**
BM	-0.0106	<.0001	<.0001	<.0001
IOR	0.0197	<.0001	<.0001	<.0001
Size	-0.0010	<.0001	<.0001	<.0001
Runup	-0.0253	<.0001	<.0001	<.0001
PastRet	-0.0003	0.7107	0.8079	0.8097

Panel B: Using the bottom 50 percent *OptVolume*

Variable	Parameter Estimate	P Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0092	0.005	0.0071	0.0108
SUE	0.1844	<.0001	<.0001	<.0001
Vspread	0.0166	<.0001	0.0023	0.0027
SUE* Vspread	**0.2235**	**0.0002**	**0.0746**	**0.0644**
BM	-0.0019	<.0001	0.0388	0.0837
IOR	0.0188	<.0001	<.0001	<.0001
Size	-0.0001	0.6581	0.6391	0.648
Runup	-0.0138	<.0001	0.0005	0.0005
PastRet	-0.0010	0.1484	0.3905	0.384

Table 7: Pre-announcement Option Volume and Stock Market Response

This table examines the confounding effect of pre-earnings option trading volume on the implications of volatility spread on the stock market response to earnings announcements using the whole sample. The regression equation is specified as follows:

$$AnnRet_{t-1,t+1} = \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot OptVolume_{t-5,t-2} + \beta_4 \cdot SUE_t \cdot Vspread_{t-5,t-2}$$
$$+ \beta_5 \cdot SUE_t \cdot OptVolume_{t-5,t-2} + \beta_6 \cdot SUE_t \cdot Vspread_{t-5,t-2} \cdot OptVolume_{t-5,t-2}$$
$$+ \beta_7 \cdot BM_{previous \text{ fiscal qtr end}} + \beta_8 \cdot IOR_{previous \text{ qtr end}} + \beta_9 \cdot Size_{previous \text{ mth end}} + \beta_{10} \cdot Runup_{t-30,t-2}$$
$$+ \beta_{11} \cdot PastRet_{t-210,t-31} + \varepsilon$$

All variables are as constructed in Table 1. For each announcement we first calculate the daily abnormal option volume by subtracting the average options trading volume over the benchmark window [t-35, t-6] from the daily option volume in the event window [t-5, t-2]. The daily abnormal option volume is then cumulated over the event window to obtain the cumulative abnormal option volume *OptVolume*. *OptVolume* is then interacted with *Vspread* and *SUE* to examine the confounding effect of pre-earnings option trading volume on the implications of volatility spread on the stock market response to earnings announcements. The regression equation is estimated using three alternative methods: the ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0032	0.1836	0.2525	0.3186
SUE	0.2223	<.0001	<.0001	<.0001
Vspread	0.0154	<.0001	0.0004	0.0004
OptVolume	0.0000	0.8467	0.82	0.8186
SUE*Vspread	**0.3629**	**<.0001**	**0.0005**	**0.0006**
*SUE*OptVolume*	-0.0158	0.1988	0.4627	0.4600
SUE*Vspread*OptVolume	**0.9726**	**<.0001**	**0.014**	**0.0123**
BM	-0.0043	<.0001	0.0002	0.0057
IOR	0.0196	<.0001	<.0001	<.0001
Size	-0.0004	0.0112	0.0103	0.0205
Runup	-0.0182	<.0001	<.0001	<.0001
PastRet	-0.0005	0.3602	0.574	0.5757

Table 8: Volatility Spread and Post-Earnings Announcement Drift (PEAD)

This table examines the confounding effect of pre-earnings option trading volume on the implications of volatility spread on the stock market response to earnings announcements using the whole sample. The regression equation is specified as follows:

$$\begin{aligned} PEAD_{t+2,t+91} &= \beta_0 + \beta_1 \cdot SUE_t + \beta_2 \cdot Vspread_{t-5,t-2} + \beta_3 \cdot OptVolume_{t-5,t-2} + \beta_4 \cdot SUE_t \cdot Vspread_{t-5,t-2} \\ &+ \beta_5 \cdot SUE_t \cdot OptVolume_{t-5,t-2} + \beta_6 \cdot SUE_t \cdot Vspread_{t-5,t-2} \cdot OptVolume_{t-5,t-2} \\ &+ \beta_7 \cdot BM_{previous \text{ fiscal qtr end}} + \beta_8 \cdot IOR_{previous \text{ qtr end}} + \beta_9 \cdot Size_{previous \text{ mth end}} + \beta_{10} \cdot Runup_{t-30,t-2} \\ &+ \beta_{11} \cdot PastRet_{t-210,t-31} + \varepsilon \end{aligned}$$

The dependent variable is the post-earnings announcement drift (PEAD), defined as the cumulative abnormal returns over [t+2, t+91], where t is the earnings announcement date. All explanatory variables are as constructed in Table 1. The regression equation is estimated using three alternative methods: the ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0207	<.0001	0.0003	0.0008
SUE	0.0166	0.2636	0.6582	0.6728
Vspread	0.0050	0.4204	0.5700	0.5671
OptVolume	0.0002	0.6876	0.5984	0.5986
*SUE*Vspread*	0.2386	0.0026	0.2176	0.2291
*SUE*OptVolume*	-0.0150	0.7466	0.8255	0.8253
*SUE*Vspread*OptVolume*	-0.0677	0.8442	0.9027	0.8985
BM	0.0108	<.0001	<.0001	<.0001
IOR	0.0395	<.0001	<.0001	<.0001
Size	-0.0009	0.0068	0.0085	0.0173
Runup	-0.0124	0.0013	0.0494	0.0480
PastRet	0.0108	<.0001	<.0001	<.0001

Table 9: Robustness Check on Table 5 Using Alternative Abnormal Return Specification

This table repeats the regression tests in Table 5 with the main difference being the dependent variable *AnnRet*. The regression equation is specified as follows:

$$AnnRet = \beta_0 + \beta_1 \cdot SUE + \beta_2 \cdot Vspread + \beta_3 \cdot SUE \cdot Vspread + \beta_4 \cdot BM + \beta_5 \cdot IOR + \beta_6 \cdot Size + \beta_7 \cdot Runup + \beta_8 \cdot PastRet + \varepsilon$$

Unlike Table 5, *AnnRet* is the announcement return calculated as the abnormal returns cumulated over [t-1, t+1], where abnormal return is defined as the raw daily return minus the return on portfolios of firms with similar size (the size decile portfolios). Returns on the size decile portfolios are available via the Wharton Research Data Service at the University of Pennsylvania. The explanatory variables are as defined in Table 5. *SUE* is the standardized unexpected earnings; *Vspread* is the cumulative abnormal implied volatility spread; *BM* is the book to market ratio; *IOR* is the institutional ownership; *Size* is the firm size; *Runup* is the pre-announcement stock price run-up; *PastRet* is the past stock return. The methodologies for constructing these variables are as outlined in Table 1. The regression equation is estimated using three alternative methods: the ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	0.0001	0.9546	0.9609	0.966
SUE	0.2167	<.0001	<.0001	<.0001
Vspread	0.0172	<.0001	<.0001	<.0001
SUE* Vspread	**0.4105**	**<.0001**	**0.0002**	**0.0002**
BM	-0.0044	<.0001	0.0002	0.0051
IOR	0.0192	<.0001	<.0001	<.0001
Size	-0.0006	0.0002	0.0001	0.0006
Runup	-0.0191	<.0001	<.0001	<.0001
PastRet	0.0002	0.7301	0.832	0.8339

Table 10: Robustness Check on Table 5 Using Alternative Design for *Vspread*

This table repeats the regression tests in Table 5 with the main difference being the main explanatory variable *Vspread*. The regression equation is specified as follows:

$$AnnRet = \beta_0 + \beta_1 \cdot SUE + \beta_2 \cdot Vspreadidx + \beta_3 \cdot SUE \cdot Vspreadidx + \beta_4 \cdot BM + \beta_5 \cdot IOR + \beta_6 \cdot Size + \beta_7 \cdot Runup + \beta_8 \cdot PastRet + \varepsilon$$

AnnRet is the announcement return as calculated in Table 1. Unlike Table 5, we construct a dummy variable *Vspreadidx* on the basis of the cumulative abnormal implied volatility spread Vspread. More specifically, all announcements are sorted into two groups using the 50^{th} percentile point of *Vspread.* The bottom group contains one half of announcements with low cumulative abnormal implied volatility spread, whereas the top group includes the other half of announcements with high cumulative abnormal implied volatility spread. *Vspreadidx* takes the value of 1 for the top group and zero otherwise. *BM* is the book to market ratio; *IOR* is the institutional ownership; *Size* is the firm size; *Runup* is the pre-announcement stock price run-up; *PastRet* is the past stock return. The methodologies for constructing these variables are as outlined in Table 1. The regression equation is estimated using three alternative methods: the ordinary least squares (OLS), robust regression using heteroscedasticity-consistent standard errors, and robust regression with firm-clustered standard errors. The estimated coefficients are presented in the second column whereas their P-values from three regression estimation methods are presented in Columns 3 to 5.

Variable	Parameter Estimate	P-Value from OLS Regression	P-Value from Robust Regression	P-Value from Clustered Std. Err.
Intercept	-0.0015	0.5319	0.5898	0.638
SUE	0.1607	<.0001	0.0001	<.0001
Vspreadidx	0.0028	<.0001	<.0001	<.0001
SUE* Vspreadidx	**0.0798**	**<.0001**	**0.002**	**0.002**
BM	-0.0043	<.0001	0.0003	0.0062
IOR	0.0192	<.0001	<.0001	<.0001
Size	-0.0006	0.0002	0.0002	0.0007
Runup	-0.0189	<.0001	<.0001	<.0001
PastRet	0.0002	0.662	0.788	0.790