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Volatility spreads and earnings announcement returns

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ABSTRACT

Prior research documents that volatility spreads predict stock returns. If the trading activity of informed investors is an important driver of volatility spreads, then the predictability of stock returns should be more pronounced during major information events. This paper investigates whether the predictability of equity returns by volatility spreads is stronger during earnings announcements. Volatility spreads are measured by the implied volatility differences between pairs of strike price and expiration date matched put and call options and capture price pressures in the option market. During a two-day earnings announcement window, the abnormal returns to the quintile that includes stocks with relatively expensive call options is more than 1.5% greater than the abnormal returns to the quintile that includes stocks with relatively expensive put options. This result is robust after measuring volatility spreads in alternative ways and controlling for firm characteristics and lagged equity returns. The degree of announcement return predictability is stronger when volatility spreads are measured using more liquid options, the information environment is more asymmetric, and stock liquidity is low.

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1. Introduction

Under standard option pricing models, an equity option's price is dictated by the price of the underlying stock. However, in incomplete markets, option prices may convey information about future stock returns if informed traders have a preference for the option market as a trading venue. Black (1975) suggests that the option market provides higher leverage for traders to exploit their private information. Option markets enhance the opportunities for taking short positions in response to bad news by limiting potential losses and investors who have private information about the volatility of the underlying equity prices can only use this information by trading options. Although there are conflicting findings in the early literature,[1] recent research presents empirical evidence that supports the conjecture that information is reflected in the option market before it is reflected in the stock market.[2]

This paper builds on prior research which finds that implied volatility spreads predict equity returns. The purpose of this study is focusing on an informationally intensive event such as the announcement of corporate earnings and investigating whether the predictability documented in the prior literature is due to informed trading. The main result is that stocks with higher (lower) put minus call implied volatility spreads before earnings announcements earn significantly negative (positive) abnormal returns during a two-day announcement window. This result cannot be solely explained by short sales restrictions. The degree of predictability is stronger under conditions when informed investors are more likely to trade in the option market.

The volatility spread between strike price and expiration date matched put and call options has been used to measure deviations from put-call parity by several studies.[3] Put-call parity is a simple no arbitrage relationship which hinges on the idea that the payoff of a stock can be synthetically replicated using call options, put options and bonds. Deviations from put-call parity do not always represent arbitrage opportunities since factors such as dividend payments, transaction costs and the early exercise premium for American options can cause call and put option prices to deviate from parity. A potential reason for these deviations is the trading activity of informed investors. Bollen and Whaley (2004) and

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[1] Manaster and Rendleman (1982), Bhattacharya (1987), Anthony (1988) and Sheikh and Ronn (1994) provide evidence that option prices and trading volume contain information not reflected in contemporaneous stock prices. However, Vijh (1988), Stephan and Whaley (1990) and Finucane (1999) challenge these findings. Chan et al. (1993) and Diltz and Kim (1996) are studies that attempt to reconcile these conflicts.

[2] See Chan et al. (2002), Chakravarty et al. (2004), Chen et al. (2005), Cao et al. (2005), Pan and Poteshman (2006), Bali and Hovakimian (2009), Chang et al. (2009), Cremers and Weinbaum (2010), An et al. (2013) and Bali and Murray (2013).

[3] See Figlewski and Webb (1993), Amin et al. (2004), Ofek et al. (2004), Broadie et al. (2007) and Cremers and Weinbaum (2010).

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Garlenau et al. (2009) introduce demand-based option pricing models where the demand for an option affects its price. When the demand for a particular option contract is strong, competitive risk-averse option market makers cannot hedge their positions perfectly and they require a premium for taking this risk. In this type of equilibrium, one would expect a positive relationship between end-user demand and option expensiveness, which can be measured by implied volatility. If some investors have private information about future price increases (decreases), then they would demand more call (put) options which will increase the implied volatilities of call (put) options with respect to put (call) options. Therefore, the difference between put and call implied volatilities would increase (decrease) before stock price decreases (increases). Options on individual stocks are American and strict put-call parity relationships take the form of an inequality due to early exercise premia. Thus, in the spirit of demand-based option pricing models, volatility spreads are just a means of capturing relative price pressures in the option market.

If the trading activity of informed traders is an important driver of option market price pressures as measured by volatility spreads, then the predictability of stock returns by these spreads should be strongly pronounced during major information events such as earnings announcements.[4] When stocks are sorted based on their volatility spreads one trading day before earnings announcements, on average, the quintile that includes stocks with the smallest put minus call volatility spreads (relatively more expensive call options) earns a five-factor adjusted abnormal return of 44 basis points whereas the quintile that includes stocks with the largest volatility spreads (relatively more expensive put options) earns a five-factor adjusted abnormal return of −38 basis points during a two-day earnings announcement window. The abnormal return difference between these two extreme quintiles is 82 basis points and highly significant. When compared to the one-week hedge portfolio return of 20 basis points that Cremers and Weinbaum (2010) uncover using the same methodology, this finding is consistent with the idea that the predictability of stock returns by volatility spreads should be stronger during periods that are informationally intensive. This result cannot be solely explained by short sales restrictions since it is a symmetric result and the quintile that holds stocks with relatively high call implied volatilites earns a significantly positive abnormal return. If the volatility spreads could solely be explained by short sales restrictions,[5] one would expect the predictability to be concentrated on stocks with relatively high put implied volatilities.

The changes in the volatility spreads in the period preceeding the earnings announcements are also investigated because the volatility spreads could change as the option market participants anticipate the magnitude and direction of the announcement returns. When stocks are double-sorted with respect to their volatility spread levels one day before the earnings announcements and the changes in their volatility spreads during the pre-announcement week, the diagonal group of equities that holds stocks with relatively expensive calls (puts) earns an abnormal return of 78 (−89) basis points. The abnormal return difference between these two extreme equity groups is 166 basis points and highly significant. The results are qualitatively similar during both halves of the sample period which indicates that the degree of announcement return predictability has stayed strong over time.

Three sets of results are presented to argue that the return predictability during the earnings announcement period reflects informed trading. Easley et al. (1998) find equilibrium conditions under which informed traders will be pooled with liquidity traders in the option market. Their model implies that when the option market is more liquid, the stock market is less liquid and the information environment is more asymmetric, informed traders will be more inclined to exploit their private information in the option market. First, when implied volatility spreads are measured using only the most liquid option pairs, the degree of announcement return predictability is higher. Second, the announcement return predictability is stronger for stocks with higher PIN values, which is a proxy for the existence of asymmetric information for a particular stock. Third, stocks with higher illiquidity ratios exhibit stronger announcement return predictability.

Panel regressions reiterate the results from the quintile analysis. After controlling for lagged stock returns and various contemporaneous and lagged firm characteristics such as market beta, firm size, book-to-market ratio and skewness, there is a significantly negative relationship between the levels of and the changes in the volatility spreads before earnings announcements and the announcement returns. Regression analysis also confirm the finding that the significantly negative relationship between volatility spreads and earnings announcement returns is stronger for stocks whose liquidity is low and probability of informed trading is high.

The paper is organized as follows. Section 2 describes the empirical methodology and data. Section 3 presents the results for the quintile analysis. Section 4 presents panel regression results for robustness check. Section 5 concludes.

2. Methodology and data

2.1. Measuring volatility spreads

The Black and Scholes (1973) implied volatilities of put and call options with the same strike prices and expiration dates should be equal for European options. This study focuses on options written on individual stocks, which are American. These options can be exercised before their expiration dates, thus their prices should reflect an early exercise premium. However, the Black–Scholes implied volatility difference between matched pairs of put and call options, adjusted for early exercise premia and dividends, can still be used to proxy for price pressures in the option market. On a particular day, there may be multiple pairs of strike price and expiration date matched put and call options written on a given stock. To construct a single volatility spread measure for each stock in each trading day, the implied volatility differences between matched put and call options are weighted by the average open interest of the call and put options in each pair.[6] Options for which open interest is non-positive and trading volume is missing are eliminated.[7] One can formulate the weighted average volatility spread for stock i on day t as follows:

$$VS_{it} = \sum_{j=1}^{N_{it}} w_{jt}(IVput_{jt} - IVcall_{jt}) \quad (1)$$

where j refers to pairs of put and call options with the same strike price and expiration date written on stock i, N_{it} refers to the number

[4] See Patell and Wolfson (1979), Donders and Vorst (1996), Amin and Lee (1997), Xing et al. (2008), Isakov and Perignon (2001) and Diavatopoulos et al. (2012) for studies that investigate other aspects of option markets such as volatility smirks, trading volumes and implied higher order moments around earnings announcements.

[5] Ofek and Richardson (2003) and Ofek et al. (2004) find that deviations from put-call parity may occur when there are limits on arbitrage such as short sales restrictions.

[6] The results are robust to using the average volume of the call and put options in each pair is as the weighting variable.

[7] Adding additional screens to the option data does not alter the results. Results are qualitatively the same after eliminating stocks whose price is less than $5, keeping only the options whose implied volatility is between 3% and 200% and whose time to expiration is within 10–60 days and deleting options whose price (average of best bid and best ask) is less than $0.125.

Table 1
Descriptive statistics for volatility spreads. This table presents various descriptive statistics for volatility spreads measured on the days preceding earnings announcements. Volatility spreads are defined as the open interest weighted average implied volatility differences between strike price and expiration date matched puts and calls across option pairs for an underlying stock. The full sample period is January 1996 to September 2008. Results are also reported for two subperiods: January 1996 to December 2002 and January 2003 to September 2008. Panel A reports the mean volatility spread (cross-sectional average of time-series means across firms) and the average time series standard deviation and skewness across firms. Panel B reports decile breakpoints. All the descriptive statistics are reported in percentages.

	Full sample	1996–2002	2003–2008
Panel A: Summary statistics			
Mean	1.057	0.955	1.137
Standard deviation	5.993	6.614	4.723
Skewness	4.671	5.776	2.642
Number of observations	66,346	29,060	37,286
Panel B: Percentiles			
10th	−3.610	−5.126	−2.602
20th	−1.510	−2.249	−1.100
30th	−0.502	−0.857	−0.318
40th	0.192	0.081	0.251
50th	0.784	0.845	0.751
60th	1.416	1.679	1.277
70th	2.210	2.692	1.924
80th	3.410	4.176	2.882
90th	5.899	6.899	5.006

of valid option pairs for stock i on day t, IV_{jt} is the implied volatility of the put or call option in option pair j and w_{jt} are the weights calculated based on the average open interest of the call option and put option in option pair j.

2.2. Data and summary statistics

The options data come from Ivy DB OptionMetrics. The database provides end-of-day bid and ask quotes, open interest, volume and implied volatility information on every call and put option on every individual stock traded on a U.S. exchange. The sample period is from January 1996 to September 2008. Mutual or investment trust funds, American depositary receipts and exchange traded funds are dropped from the sample. At the beginning of the sample period, there are about 600,000 option observations per month. The number of observations increases to about 4,000,000 per month at the end. OptionMetrics calculates implied volatilities using a binomial tree based on closing option prices and interest rates derived from LIBOR rates and settlement prices of Eurodollar futures after taking dividend payments and early exercise premia into account.[8] The data for share prices, daily stock returns and number of shares outstanding come from CRSP.[9] Earning announcement dates (day 0) and book value of equity data are from COMPUSTAT.[10]

Table 1 presents descriptive statistics for volatility spreads measured on the trading day preceeding earnings announcements. The descriptive statistics are provided for the full sample and two subperiods (1996–2002 and 2003–2008). The final sample consists of 66,346 earnings announcement dates for 3588 unique firms. There are 29,060 announcements in the first subperiod and 37,286 announcements in the second subperiod. Panel A shows that the average volatility spread for the full sample is 1.06% indicating that put options were more expensive than call options on average. The average time-series standard deviation across firms is 5.99% indicating substantial variation. Volatility spreads are highly right-skewed and the degree of skewness is lower in the second subperiod.

Panel B presents the deciles of the distribution of volatility spreads. In the full sample, the 10th percentile of volatility spreads is −3.61% and the 90th percentile is 5.90%. This implies that volatility spreads are more pronounced in the direction of relatively more expensive puts. The subperiod summary statistics indicate that volatility spreads have become less pronounced in the later subperiod. The 10th percentile of volatility spreads increases from −5.13% to −2.60% whereas the 90th percentile of volatility spreads decreases from 6.90% to 5.01%.

Table 2 presents pre-formation characteristics and performances for quintiles formed based on the level of volatility spreads. Letting the earnings announcement date to be day 0, the volatility spreads are measured on day −1. Earnings announcements are grouped by the months in which they are made in order to construct these quintiles. Averages of various characteristics for each quintile are calculated using this monthly system and then grand averages are formed over the full sample period. Doing so reduces the clustering of good or bad news in time. It should be noted that this methodology does not generate tradeable equity portfolios since the quintiles are not formed in calendar time and they are rather constructed with respect to an event date. At the beginning of the sample period, there are 69 firms in each volatility spread quintile. This number increases to 170 firms at the end of the sample.

Panel A reports pre-formation characteristics for the equity quintiles. Stocks in quintile 1 (with relatively expensive calls) have a market capitalization of $3.3 billion and stocks in quintile 5 (with relatively expensive puts) have a market capitalization of $2.9 billion whereas stocks in quintile 3 have a market capitalization of $9.6 billion on average. Stocks in the extreme quintiles are more volatile.[11] Market-to-book ratios increase monotonically as one goes from quintile 1 to 5. The skewness of the quintile returns is also important since volatility spreads may be related to higher moments of the underlying risk-neutral return distributions. Quintile 1 and quintile 5 have higher skewness coefficients compared to the other quintiles. These summary statistics highlight the importance of controlling for various equity characteristics such as size, market-to-book and skewness in the subsequent analysis.

Panel B reports the value-weighted weekly pre-formation returns for the equity quintiles. Both raw returns and returns in excess of the NYSE/AMEX/NASDAQ index provided by CRSP are reported. Since the volatility spreads are measured on day −1, the one-week lagged return is measured from the closing of day −7 to the closing of day −2. The excess return for quintile 1 during the week preceeding the quintile formation is −65.7 basis points whereas the excess return for quintile 5 is 107.6 basis points for quintile 5. The weekly excess return difference between quintile 1 and 5 during the week before quintile formation is −173.3 and highly significant with a t-statistic of −8.22. The excess returns during the second, third and fourth weeks before the quintiles are formed also increase almost monotonically from quintile 1 to quintile 5, but the return differences between the extreme

[8] Implied volatilities are not calculated when an option contract has non-standard settlement or a vega below 0.5. Moreover, if the midpoint of the option's bid/ask price is below intrinsic value or the underlying stock's price is not available, OptionMetrics does not report a value for implied volatility.

[9] OptionMetrics and CRSP data are merged following Duarte et al. (2005). Specifically, it is required that the current CUSIP of a stock from OptionMetrics be in the historical record of CUSIP's from CRSP. Observations for which the security identifier from CRSP (PERMNO) is assigned to more than one security identifier from OptionMetrics (SECID) are deleted. Stocks that appear in CRSP later than OptionMetrics and that have options appearing in OptionMetrics after their last day of appearance in CRSP are also deleted.

[10] Financial firms and securities with CRSP share codes other than 10 or 11 are excluded from the sample.

[11] The standard deviation and skewness of quintile returns are calculated over the year preceeding the quintile formation.

Table 2
Quintile characteristics and performances before earnings announcements. This table presents pre-formation characteristics and performances for equity quintiles formed based on volatility spreads as defined in Table 1. Every month, stocks are sorted into quintiles based on their volatility spreads one day before their earnings announcement dates. Panel A shows the pre-formation average market value of equity (in $ millions), market-to-book ratio, standard deviation and skewness (both estimated over the pre-announcement year) for each quintile. Panel B presents the pre-formation value-weighted quintile returns over the first, second, third and fourth weeks preceeding the earnings announcements. This panel reports average returns and average returns in excess of the NYSE/AMEX/NASDAQ index in basis points and *t*-statistics associated with the excess returns. The last two columns represent the average and excess return differences between the extreme volatility spread quintiles and *t*-statistics associated with these differences, respectively. All *t*-statistics are adjusted following Newey and West (1987).

		Volatility spread quintiles					(1–5)	*t*-Stat.
		1	2	3	4	5		
Panel A: Pre-formation characteristics								
Market value of equity		3,285.42	7,772.66	9,633.85	7,570.95	2,946.26		
Market-to-book ratio		2.17	2.39	2.52	2.44	3.74		
Standard deviation		0.034	0.028	0.027	0.029	0.034		
Skewness		0.192	0.177	0.137	0.178	0.224		
Panel B: Pre-formation performance								
First week	Mean return	−61.79	102.74	76.22	118.15	134.83	−196.62	[−6.26]
	Excess return	−65.67	4.73	61.12	95.5	107.58	−173.25	[−8.22]
	t-Stat	[−4.29]	[0.45]	[5.99]	[9.68]	[7.42]		
Second week	Mean return	13.84	24.98	23.58	50.13	38.46	−24.62	[−0.84]
	Excess return	−4.07	6.78	5.46	32.67	26.63	−30.70	[−1.50]
	t-Stat	[−0.28]	[0.72]	[0.58]	[2.78]	[1.86]		
Third week	Mean return	−4.36	26.92	40.43	44.74	23.61	−27.97	[−0.94]
	Excess return	−25.73	4.09	18.19	24.64	3.83	−29.56	[−1.45]
	t-Stat	[−1.66]	[0.41]	[1.71]	[2.50]	[0.29]		
Fourth week	Mean return	3.11	7.89	16.43	37.86	38.29	−35.18	[−1.19]
	Excess return	−18.37	−10.85	1.46	17.62	19.47	−37.84	[−1.82]
	t-Stat	[−1.21]	[−1.27]	[0.16]	[1.62]	[1.37]		

quintiles are not significant. The finding that stocks with relatively expensive call options perform significantly worse than stocks with relatively expensive put options during the pre-announcement week is important. This study argues that stocks with relatively expensive call options should have higher returns than stocks with relatively expensive put options during earnings announcements. Therefore, the volatility spread strategy proposed in this paper is contrarian. Lagged weekly stock returns are controlled for in the panel regressions of Section 4 so that the predictive ability of volatility spreads for earnings announcement returns can be distinguished from short-term reversal patterns in stock prices.

3. Empirical results

This section investigates the earnings announcement return performances of quintiles formed based on levels and/or changes in volatility spreads preceeding the announcement dates. The analysis is repeated in two subperiods to see whether the findings are similar over time. It is also investigated whether the predictive power of volatility spreads is stronger when spreads are measured using more liquid options, when the underlying stock is less liquid or it has a more asymmetric information environment.

3.1. Post-formation returns of volatility spread quintiles

In the following analyis, stocks are sorted into quintiles based on their implied volatility spread signals preceeding the earnings announcements. Letting the earnings announcement date to be day 0, the earnings announcement window is defined to be days 0 and 1[12] and the announcement period returns are measured as the returns on the underlying stocks during these two days. The levels of and changes in the volatility spreads are measured and quintiles are formed on day −1. One empirical concern is that the non-synchronicity between option and stock markets may bias research results.[13] To alleviate this concern, the tests ignore overnight returns, measure the option signals based on the closing option prices on day −1 and start accruing the announcement returns from the opening of day 0.

Table 3 presents the post-formation returns of equity quintiles formed in alternative ways. The first set of results are based on the levels of the volatility spreads. Quintile 1 which contains stocks with relatively expensive call options earns an average return of 58.7 basis points during the earnings announcement window. In contrast, quintile 5 which contains stocks with relatively expensive put options earns an average return of −34.1 basis points. The difference between the returns of these two extreme quintiles is 92.8 basis points with a highly significant *t*-statistic of 5.58. This result lends initial support to the hypothesis that volatility spreads predict earnings announcement returns.

To rule out the possibility that this difference is driven by differences in equity risk, abnormal returns are calculated using a five-factor model that includes market, size and book-to-market factors as in Fama and French (1993), a momentum factor as in Carhart (1997) and a total skewness factor.[14,15] Specifically, for each stock, we regress daily returns during the last twelve months on these five factors and calculate the expected return of each stock during the announcement window using the coefficients of these regressions as factor loadings. The abnormal returns are defined as the difference between the actual returns and expected returns. One can see that the abnormal returns to the quintiles decrease monotonically from

[12] The results are robust to alternative earnings announcement window specifications such as (−4,1), (−4,3), (−1,1), (−1,3) and (0,3).

[13] The Chicago Board of Option Exchange closed at 4:10 PM EST until June 22nd, 1997 and at 4:02 PM EST after that date. In contrast, stock exchanges close at 4:00 PM EST. Battalio and Schultz (2006) look at intraday options data to argue that the findings of Ofek et al. (2004) are driven by non-synchronous prices inherent in the OptionMetrics database.

[14] The skewness factor is constructed by ranking stocks based on the total skewness of their daily returns during the past year and forming three portfolios. The skewness factor is equal to the value-weighted return on the hedge portfolio which buys 30% of the stocks with the most negative skewness and sells 30% of the stocks with the most positive skewness.

[15] The data for the market, size, book-to-market and momentum factors come from Ken French's online data library.

Table 3
Returns on quintiles formed based on volatility spread signals. This table presents earnings announcement returns for equity quintiles formed based on various pre-announcement volatility spread signals. The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. Value-weighted returns, abnormal returns and *t*-statistics associated with abnormal returns are reported for each volatility spread quintile. Abnormal returns are with respect to the market, size, book-to-market (Fama and French (1993)), momentum (Carhart (1997)) and skewness factors. In "Level" results, quintiles are formed based on the level of the volatility spreads one day before the earnings announcement dates. In "Change" results, quintiles are formed based on the change in volatility spreads during the pre-announcement week. "Level/Change" results are associated with double-sorts based on both volatility spread levels and volatility spread changes. The last two columns represent the raw return and abnormal return differences between the extreme volatility spread quintiles and *t*-statistics associated with these differences. All *t*-statistics are adjusted following Newey and West (1987).

		Volatility spread quintiles					(1–5)	
		1	2	3	4	5	Return	Abnormal ret
Level	*Return*	58.73	43.59	10.94	15.30	−34.10	92.84	81.51
	Abnormal ret	43.63	35.92	7.27	13.23	−37.88	[5.58]	[5.15]
	t-Stat	[3.69]	[3.06]	[0.70]	[1.18]	[−3.00]		
		1	2	3	4	5		
Change	*Return*	53.65	35.11	35.99	−5.80	−22.54	76.19	70.84
	Abnormal ret	42.64	27.61	29.95	−8.27	−28.20	[4.77]	[4.36]
	t-Stat	[3.00]	[2.44]	[2.80]	[−0.85]	[−2.33]		
		1, 1	2, 2	3, 3	4, 4	5, 5		
Change/level	*Return*	97.47	12.67	50.29	−12.97	−85.13	182.61	166.30
	Abnormal ret	77.66	4.17	51.31	−11.53	−88.64	[4.93]	[4.48]
	t-Stat	[3.11]	[0.19]	[2.51]	[−0.47]	[−2.98]		

quintile 1 to quintile 5. The abnormal return for quintile 1 is 43.6 basis points whereas the abnormal return for quintile 5 is −37.9 basis points. The difference between the abnormal returns is 81.5 basis points with a *t*-statistic of 5.15.[16]

Cremers and Weinbaum (2010) conduct the same analysis by forming weekly portfolios based on volatility spread signals and investigate the one-week ahead returns of these portfolios. However, they do not condition their analysis on earnings announcements which are informationally intensive periods. They uncover a weekly abnormal return difference of 21 basis points between two extreme volatility spread portfolios. In contrast, this study focuses on earnings announcements and finds that the abnormal return difference between extreme volatility spread quintiles is 81.5 basis points during a two-day announcement window. This highlights the importance of focusing on significant information releases when investigating the predictive power volatility spreads on equity returns.

Our explanation for these findings is that investors with favorable (unfavorable) private information about the contents of an earnings announcement trade in the option markets in such a way that they bid up the prices of call (put) options with respect to the prices of put (call) options prior to the announcement. When the favorable (unfavorable) private information materializes, stocks with low (high) put minus call implied volatility spreads experience positive (negative) returns during earnings announcements. This information-based explanation is what lies at the core of our study. An alternative explanation is based on short-selling constraints. Short-sale restrictions may drive option prices away from model values for stocks that are expected to experience negative returns even in the absence of differential information flow towards option and stock markets. However, this explanation would only be applicable for stocks in quintile 5 that have high put minus call implied volatility spreads before the announcements and earn negative returns during the announcements. Our result is a symmetric result and stocks in quintile 1 that have low put minus call volatility spreads before the announcements earn positive returns during the announcements. Therefore, our findings cannot be solely explained by short-sale restrictions. The subsequent analysis provides additional support for the information-based explanation.

Alternative measures for the levels of the volatility spreads are also considered. Rather than measuring the levels of the volatility spreads on day −1, average volatility spreads are calculated over the week preceeding the earnings announcements and quintiles are formed based on this alternative measure.[17] Moreover, these average weekly volatility spreads are scaled by the average volatility spreads for each stock over the month preceeding the announcements. Unreported results show that when volatility spread quintiles are formed based on the average volatility spreads during the pre-announcement week, the abnormal return difference between extreme volatility spread quintiles is 44.3 basis points (*t*-statistic = 2.39). When the scaled average weekly volatility spreads are used to form quintiles, the abnormal return difference becomes 56.2 basis points (*t*-statistic = 2.91).

The next set of results in Table 3 are based on quintiles formed by sorting stocks according to the changes in their volatility spreads during the pre-announcement week. These changes are measured from the end of day −6 to the end of day −1 and the announcement returns start accruing from the opening day 0. Quintile 1 which contains stocks whose put minus call volatility spreads decrease most during the pre-announcement week earns a five-factor adjusted abnormal return of 42.6 basis points with a *t*-statistic of 3.00. The abnormal return for quintile 5 is −28.2 with a *t*-statistic of −2.33. The abnormal return difference between the extreme volatility spread change quintiles is 70.8 with a *t*-statistic of 4.36. These results suggest that volatility spreads change due to the anticipation of announcement returns during the pre-announcement week.

The final set of results in Table 3 consider both the levels of and the changes in volatility spreads. One would expect to find a larger abnormal return difference between stocks whose implied volatility spreads are lowest on day −1 and decrease most during the pre-announcement week and stocks whose implied volatility spreads are highest on day −1 and increase most during the pre-announcement week. The empirical results are consistent with this expectation. 25 Groups of equities are constructed by first sorting stocks into quintiles based on the level of their volatility spreads on day −1 and then sorting them into five additional groups based on the changes in their volatility spreads from day −6 to day −1. Table 3 reports the post-formation performances of the diagonal equity groups that are constructed according to this double-sorting

[16] The month-by-month and quarter-by-quarter analysis reveals that the predictability of announcement returns is stronger during the last quarter and especially for the announcements done in December.

[17] Stocks with at least two daily implied volatility spread observations during the pre-announcement week are considered.

procedure. Quintile (1,1) which includes stocks with relatively expensive call options earns a five-factor adjusted abnormal return of 77.7 basis points (t-statistic = 3.11). On the other hand, quintile (5,5) which includes stocks with relatively expensive put options earns an abnormal return of −88.6 basis points (t-statistic = −2.98). The abnormal return difference between the extreme quintiles is 166.3 basis points and highly significant. These results also cannot be explained by short sale constraints as both extreme quintiles have abnormal returns significantly different from zero. Cremers and Weinbaum (2010) uncover an abnormal weekly return of 50 basis points for the same strategy, again highlighting the importance of focusing on information events.

3.2. Subsample analysis

On one hand, it is possible that the degree of announcement return predictability has declined over time. Stock prices may adjust only gradually to the private information brought by informed investors, however, the public information embedded in option prices should be reflected in stock prices immediately. In the absence of serious market frictions, one would expect sophisticated investors to learn to exploit the predictability of announcement returns gradually. On the other hand, informed traders may have started using more synthetic short positions over time since derivative markets have historically become more popular and liquid as evidenced by the increased diversity of available contracts and the exponential growth in trading volumes. If more and more investors recognize option markets as a potential venue to reflect their private information and actually begin trading in these markets over time, the predictability of announcement returns by volatility spreads may get stronger in the later periods since more information will get impounded into option prices before earnings announcements. In this section, the full sample is separated in two subperiods and whether the predictability of announcement returns persists through time is investigated.

Panel A of Table 4 focuses on the subperiod from January 1996 to December 2002. When quintiles are formed based on the levels of the volatility spreads on day −1, the abnormal return difference between the extreme quintiles is 80.5 basis points (t-statistic = 3.74). When the quintiles are formed based on the changes in the volatility spreads during the pre-announcement week, the abnormal return difference between the extreme quintiles is 81.1 basis points (t-statistic = 3.98). Finally, double-sorting reveals an abnormal return difference of 184.3 basis points (t-statistic = 3.64) between the two extreme diagonal equity groups. In Panel B of Table 4, the same analysis is conducted for the second subperiod from January 2003 to September 2008. When the quintiles are constructed based on the volatility spread levels on day −1, the abnormal returns of stocks with relatively expensive call options are 82.7 basis points (t-statistic = 3.52) more than those of stocks with relatively expensive put options. When the changes in volatility spreads during the pre-announcement week are used to construct the quintiles, the abnormal return difference becomes 58.3 basis points (t-statistic = 2.22). Finally, double-sorting generates an abnormal return difference of 144.4 basis points (t-statistic = 2.64). Although there is some decrease in the abnormal return difference between the extreme quintiles in the second subperiod, the abnormal return differences continue to be statistically significant. The results from the subsample analysis suggest that the degree of earnings announcement return predictability has stayed strong over time.

3.3. The role of option liquidity

The sequential trading model of Easley et al. (1998) predicts that informed investors will prefer to exploit their private informa-

Table 4
Subsample analysis. This table presents earnings announcement returns for equity quintiles formed based on various pre-announcement volatility spread signals. Results are presented for two subperiods. Panel A reports results for the subperiod from January 1996 to December 2002. Panel B reports results for the subperiod from January 2003 to September 2008. The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. Value-weighted returns, abnormal returns and t-statistics associated with abnormals are reported for each volatility spread quintile. Abnormal returns are with respect to the market, size, book-to-market (Fama and French (1993)), momentum (Carhart (1997)) and skewness factors. In "Level" results, quintiles are formed based on the level of the volatility spreads one day before the earnings announcement dates. In "Change" results, quintiles are formed based on the change in volatility spreads during the pre-announcement week. "Level/Change" results are associated with double-sorts based on both volatility spread levels and volatility spread changes. The last two columns represent the raw return and abnormal return differences between the extreme volatility spread quintiles and t-statistics associated with these differences. All t-statistics are adjusted following Newey and West (1987).

		Volatility spread quintiles					(1–5)	
		1	2	3	4	5	Return	Abnormal ret
Panel A (1996–2002)								
Level	*Return*	77.07	36.60	6.50	29.20	−9.40	86.49	80.50
	Abnormal ret	59.45	29.61	−5.46	22.97	−21.04	[3.67]	[3.74]
	t-Stat	[3.84]	[1.77]	[−0.36]	[1.28]	[−1.17]		
		1	2	3	4	5		
Change	*Return*	68.05	48.33	30.62	1.77	−11.63	79.68	81.13
	Abnormal ret	55.75	39.46	21.00	−2.93	−25.38	[3.87]	[3.98]
	t-stat	[2.91]	[2.48]	[1.39]	[−0.21]	[−1.49]		
		1, 1	2, 2	3, 3	4, 4	5, 5		
Change/level	*Return*	109.10	0.82	51.60	9.77	−82.43	191.53	184.30
	Abnormal ret	88.49	−4.87	48.70	5.71	−95.81	[3.78]	[3.64]
	t-Stat	[2.61]	[−0.14]	[1.54]	[0.16]	[−2.38]		
Panel B (2003–2008)								
Level	*Return*	36.40	52.10	23.45	−1.63	−64.16	100.56	82.74
	Abnormal ret	24.37	43.60	22.77	1.44	−58.38	[4.31]	[3.52]
	t-Stat	[1.35]	[2.67]	[1.70]	[0.12]	[−3.36]		
		1	2	3	4	5		
Change	*return*	36.12	19.02	42.54	−15.17	−35.83	71.94	58.30
	abnormal ret	26.67	13.19	40.85	−14.78	−31.63	[2.86]	[2.22]
	t-stat	[1.36]	[0.83]	[2.71]	[−1.08]	[−1.84]		
		1, 1	2, 2	3, 3	4, 4	5, 5		
Change/level	*Return*	83.32	27.11	48.69	−40.66	−88.42	171.74	144.39
	Abnormal ret	64.48	15.19	54.49	−32.51	−79.92	[3.14]	[2.64]
	t-stat	[1.98]	[0.60]	[2.28]	[−0.96]	[−1.80]		

Table 5
The role of option liquidity. This table presents earnings announcement returns for equity quintiles formed based on pre-announcement day volatility spread levels calculated using options with different liquidity characteristics. For every stock, all option pairs are sorted into three groups based on the average liquidity of the pair on the pre-announcement day and separate volatility spread measures are calculated using option pairs of low and high liquidity. Liquidity of an option pair is measured using either its average bid/ask spread (Panel A) or its average volume (Panel B). The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. Value-weighted returns, abnormal returns and *t*-statistics associated with abnormal returns are reported for each volatility spread quintile. Abnormal returns are with respect to the market, size, book-to-market (Fama and French (1993)), momentum (Carhart (1997)) and skewness factors. The last two columns represent the raw return and abnormal return differences between the extreme volatility spread quintiles and *t*-statistics associated with these differences. All *t*-statistics are adjusted following Newey and West (1987).

		Volatility spread quintiles					(1–5)	
		1	2	3	4	5	Return	Abnormal ret
Panel A: Bid/ask spread								
More liquid	*Return*	66.37	48.13	8.65	17.38	−39.27	105.64	94.86
	Abnormal ret	51.32	41.08	2.27	9.07	−43.54	[7.23]	[6.04]
	t-Stat	[3.91]	[3.12]	[0.11]	[0.41]	[−2.84]		
Less liquid	*return*	39.12	29.23	14.66	17.82	−21.22	60.34	46.77
	Abnormal ret	26.93	19.33	6.02	7.29	−19.84	[2.43]	[1.72]
	t-Stat	[2.12]	[1.77]	[0.40]	[0.47]	[−1.39]		
Panel B: Volume								
More liquid	*Return*	80.24	43.59	10.94	15.30	−23.25	103.49	90.36
	Abnormal ret	60.17	31.91	14.02	8.55	−30.19	[6.27]	[5.47]
	t-Stat	[4.04]	[2.74]	[0.48]	[0.38]	[−1.74]		
Less liquid	*Return*	23.12	24.16	15.21	3.26	−24.98	48.10	35.56
	Abnormal ret	18.22	31.07	8.16	5.99	−17.34	[1.52]	[1.22]
	t-Stat	[0.91]	[1.27]	[0.36]	[0.19]	[−0.89]		

tion by trading options when the option markets are more liquid. Thus, if volatility spreads can predict earnings announcement returns, one would expect this predictability to be stronger when the spreads are measured using more liquid options. In this subsection, all option pairs written on a particular stock on the day preceeding the earnings announcement are sorted into three groups based on the average liquidity of the option pair. The open interest weighted volatility spread measures for each stock on a given day are first calculated using only the set of most liquid option pairs and then using only the set of least liquid option pairs. This procedure gives us two separate volatility spread measures for a given stock each day and these two volatility spread measures are different from each other based on the liquidity of the option pairs that are used in their construction. The aim of this analysis is to investigate whether there is any difference in announcement return predictability when volatility spreads are constructed using options of varying liquidity.

In Panel A of Table 5, the liquidity of each option pair is measured by the average bid-ask spread of its constituent call and put option. When the average bid-ask spread is low, the option pairs are deemed to be more liquid. For option pairs with low average bid-ask spreads, quintile 1 which includes stocks with low implied volatility spreads on day −1 earns an abnormal return of 51.3 basis points whereas quintile 5 which includes stocks with high implied volatility spreads on day −1 earns an abnormal return of −43.5 basis points. The abnormal returns to both of these extreme quintiles is highly significant. The abnormal return difference between the two quintiles is 94.9 basis points with a *t*-statistic of 6.04. In contrast, when volatility spreads are measured using option pairs with high bid-ask spreads, the abnormal return difference between the two quintiles is 46.7 basis points with a *t*-statistic of 1.72. The difference between the extreme quintile abnormal return differences among the cases where volatility spreads are measured using more liquid versus less liquid options is 48.1 basis points and significant. These findings suggest that volatility spreads have stronger predictive power for announcement returns when more liquid option pairs are used to construct the spreads.

In Panel B of Table 5, the liquidity of each option pair is measured by the average volume of the call and the put in the option pair. When option pairs with high average volumes are used to measure volatility spreads, the abnormal return difference between extreme volatility spread quintiles is 90.4 basis points (*t*-statistic = 5.47). In contrast, this abnormal return difference shrinks to 35.6 basis points (*t*-statistic = 1.22) when only option pairs with low average volumes are used. The difference between extreme quintile abnormal return differences among the two cases is 54.8 basis points and again significant. These empirical findings highlight the importance of option liquidity for the predictability of earnings announcement returns and supports the conjecture that informed traders are more inclined to use the option market when options provide higher liquidity.

3.4. The roles of information asymmetry and stock liquidity

When there is more information asymmetry associated with a particular stock, it is more likely that informed traders will use the option market according to Easley et al. (1998). Therefore, one may expect the degree of earnings announcement predictability to be stronger when the degree of information asymmetry for a stock is greater. We use the PIN measure of Easley et al. (2002) to measure informational asymmetries.[18] PIN is a measure of the fraction of trades that come from informed traders and, as such, it has been frequently used as a measure of the magnitude of private information in the markets. When PIN is high, this means that there is more private information available for a stock. The more the private information, the likelier it is that informed investors will reflect some private information in the option markets before the stock markets.

In Panel A of Table 6, the absolute value of each volatility spread on day −1 for each firm-month is regressed on the PIN values and the logarithm of firm size. The liquidity of each stock is controlled for since small stocks are expected to be less liquid and have less liquid options which may result in wider arbitrage bounds.[19] Average proportional bid-ask spreads in calls and puts are also included

[18] I would like to thank Stephen Brown from New York University for sharing his PIN dataset.

[19] In these regressions, the Amihud (2002) illiquidity ratio is used to proxy for the liquidity of each stock. The results in this study are qualitatively similar when Amivest liquidity ratio (Amihud et al. (1997)) or Pastor and Stambaugh (2003) reversal measure are used. This data is obtained from Joel Hasbrouck's website.

Table 6
The roles of information asymmetry and stock liquidity. Panel A presents the regressions of absolute values of individual volatility spreads and relative volatility spreads on PIN (probability of informed trading), Amihud (2002) illiquidity ratio, size defined as the log of market value of equity and the average proportional bid-ask spreads in calls and puts. Relative volatility spread is equal to the difference between each volatility spread and the median volatility spread across all stocks during a particular month. The *t*-statistics reported in the panel are based on robust standard errors clustered by firm. Panel B (Panel C) presents abnormal return differences during earnings announcements between extreme quintiles formed based on double-sorts using PIN (Amihud illiquidity ratio) and volatility spread levels on the pre-announcement day and the *t*-statistics associated with these abnormal return differences. The *t*-statistics reported in Panels B and C are adjusted following Newey and West (1987). The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. Abnormal returns are with respect to the market, size, book-to-market (Fama and French (1993)), momentum (Carhart (1997)) and skewness factors.

	Volatility spread	Volatility spread	Rel. vol. spread	Rel. vol. spread
Panel A				
Intercept	0.1207	0.0952	0.1178	0.0962
	[34.67]	[29.13]	[32.90]	[29.43]
PIN		0.0138		0.0131
		[2.17]		[2.08]
Illiquidity ratio		0.0599		0.0609
		[3.98]		[4.07]
Size	−0.0101	−0.0084	−0.0102	−0.0087
	[−26.13]	[−23.24]	[−25.63]	[−23.81]
Call spread	0.0732	0.0658	0.0714	0.0652
	[13.21]	[11.95]	[12.89]	[11.44]
Put spread	0.0237	0.0192	0.0231	0.0187
	[5.27]	[4.51]	[5.09]	[4.60]
				(1–5)
Panel B				
PIN (low)		*Abnormal ret*		18.74
		t-Stat		[0.72]
PIN (2)		*Abnormal ret*		16.81
		t-Stat		[0.49]
PIN (3)		*Abnormal ret*		56.21
		t-Stat		[1.33]
PIN (4)		*Abnormal ret*		127.06
		t-Stat		[2.62]
PIN (high)		*Abnormal ret*		122.80
		t-stat		[3.88]
Panel C				
Liquidity (high)		*Abnormal ret*		56.22
		t-Stat		[1.50]
Illiquidity (2)		*Abnormal ret*		87.82
		t-Stat		[2.65]
Illiquidity (3)		*Abnormal ret*		17.80
		t-Stat		[0.43]
Illiquidity (4)		*Abnormal ret*		65.95
		t-Stat		[1.36]
Liquidity (low)		*Abnormal ret*		191.51
		t-Stat		[4.31]

in the specification since these microstructural variables may also affect the magnitude of volatility spreads. The *t*-statistics presented in the table are based on robust standard errors clustered by firm. The results show that firms with higher PIN values tend to have larger volatility spreads in absolute magnitude. Relative volatility spreads for each firm-month are also calculated as the absolute value of the difference between each volatility spread and the median volatility spread across all stocks during that particular month. When relative volatility spreads are regressed on PIN and the control variables, the coefficient of PIN is still significantly positive.

Next, the conjecture that the degree of earnings announcement return predictability is stronger for stocks with higher PIN values is tested by double-sorting stocks with respect to their PIN values and their volatility spread levels on the day before the announcement date. The results are presented on Panel B of Table 6. The abnormal return difference between extreme volatility spread quintiles is 18.7 basis points with a *t*-statistic of 0.72 for the lowest PIN quintile during the two-day announcement window. However, these abnormal returns increase almost monotonically moving to the higher PIN quintiles. For the quintile which contains stocks with the highest PIN values, the abnormal return difference between extreme volatility spread quintiles increases to 122.8 basis points with a *t*-statistic of 3.88. These results suggest that information asymmetry measured by the probability of informed trading has an important role in the predictability of announcement returns by volatility spreads.

Another prediction of the sequential trading model of Easley et al. (1998) is that informed investors would be more inclined to trade options when the liquidity of the underlying equities is lower. The regression in Panel A of Table 6 includes the Amihud illiquidity ratio as an independent variable. After controlling for firm size, probability of informed trading and average bid-ask spreads in call and put options, the illiquidity ratio and the absolute value of the volatility spreads are positively and significantly related. Panel C tests whether the predictive power of volatility spreads for announcement returns is stronger when the liquidity of the underlying stocks is lower. Double-sorts on illiquidity ratios and volatility spreads are considered for this purpose. For the quintile which includes the most liquid stocks, the abnormal return difference between the extreme volatility spread quintiles is 56.2 basis points with a *t*-statistic of 1.50. Although the abnormal returns do not change monotonically from the highest stock liquidity quintile to the lowest stock liquidity quintile, it is noteworthy that the abnormal return difference between the extreme volatility spread quintiles for the stocks with the lowest liquidity is 191.5 basis points with a *t*-statistic of 4.31. These results support the hypothesis that informed traders prefer using the options market when the underlying stocks are less liquid.

4. Regression analysis

Previous analyses provide evidence that volatility spreads predict earnings announcement returns and this predictability is stronger under conditions when informed investors are more likely to exploit their private information in the option markets. This section reexamines these quintile level results in a panel regression setting after controlling for various firm specific variables and past stock returns.

4.1. Predictability of earnings announcement returns

Table 7 presents the results for pooled panel regressions to investigate the ability of volatility spreads to predict stock returns during earnings announcement periods. The dependent variable in all the regressions is the individual stock returns from the opening of the earnings announcement date to the closing of the next trading day. Various contemporaneous and lagged control variables are included in the regressions to make sure that the results are not driven by firm-specific characteristics. These characteristics are market beta calculated from daily returns over the past twelve months to control for the market risk inherent in the Capital Asset Pricing Model of Sharpe (1964) and Lintner (1965), firm size as measured by the market value of equity to capture the size effect of Banz (1981) which suggests that small firms earn a premia over large firms, book-to-market ratio to capture the value effect of Fama and French (1992) which suggests that value firms earn a premia over growth firms, one-month return in the pre-announcement period to control for the momentum effect of Jegadeesh and Titman (1993) which suggests that past winners continue to outperform past losers over the intermediate horizon and skewness measured from daily returns over the past twelve months to control for the third moment of the realized return distribution which has been shown to impact expected equity returns by Kraus and Litzenberger (1976). Lagged weekly stock returns (from day −6 to day −1) and lagged firm characteristics are also added to all the specifications to control for any autocorrelation and short-term reversal associated with stock returns. The *t*-statistics reported in the table are based on robust standard errors clustered by firm.

The first column in Table 7 includes the level of the volatility spread one day before the earnings announcement date in the regression specification. The coefficient of the level of the volatility spread is significantly negative. In the second regression, the change in the volatility spread during the pre-announcement week is used rather than the level of the volatility spread. There is also a significantly negative relationship between changes in the volatility spreads and future announcement returns. In the third regression, both the level of and the change in the volatility spreads are included in the regressions. Both variables have significantly negative coefficients indicating that the information captured by both volatility spread signals matter and their impacts on announcement returns are distinct. These results are consistent with the findings from the quintile analyses.

The last three regressions replace the levels of and changes in volatility spreads by quintile dummies. Stocks are again sorted into quintiles based on their volatility spread signals before the earnings announcements. The announcement returns are regressed on the control variables and the quintile dummies. In the fourth column, the quintile dummies for the volatility spread levels are included in the specification. The coefficient associated with the lowest quintile dummy is significantly positive indicating an abnormal return of 30 basis points for these stocks. In contrast, the coefficient associated with the highest quintile dummy is significantly negative indicating an abnormal return of −40 basis points for these stocks. The abnormal return difference between these two extreme quintiles is 70 basis points. In the fifth column, the quintile dummies are based on the changes in the volatility

Table 7
Panel regressions. This table presents results for panel regressions of earnings announcement returns on various volatility spread signals or quintile dummies formed based on these signals. In the first three columns, volatility spread levels on the pre-announcement day and/or volatility spread changes during the pre-announcement week are included in the specification. In the last three columns, quintile dummies formed based on these volatility spread levels and/or changes replace the actual values of volatility spread signals. The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. All specifications include contemporaneous and lagged values of market beta calculated from daily returns over the past twelve months, firm size as measured by the market value of equity, book-to-market ratio, one-month return in the pre-announcement period and skewness measured from daily returns over the prior year as control variables. The stock returns during the pre-announcement week are also controlled for in each specification. The *t*-statistics are based on robust standard errors clustered by firm.

	1	2	3	4	5	6
Intercept	0.0023	0.0019	0.0023	0.0017	0.0023	0.0019
	[5.96]	[5.26]	[5.99]	[2.59]	[3.47]	[2.28]
Level of volatility spread	−0.0309		−0.0265			
	[−5.05]		[−4.17]			
Change of volatility spread		−0.0189	−0.0125			
		[−3.33]	[−2.13]			
Dummy Q1 – level				0.0030		0.0029
				[2.88]		[2.60]
Dummy Q2 – level				0.0021		0.0020
				[2.21]		[2.01]
Dummy Q4 – level				−0.0003		0.0001
				[−0.28]		[0.00]
Dummy Q5 – level				−0.0040		−0.0034
				[−3.77]		[−2.89]
Dummy Q1 – change					0.0014	0.0013
					[1.29]	[1.02]
dummy Q2 - change					0.0011	0.0004
					[1.12]	[0.42]
Dummy Q4 – change					−0.0008	−0.0002
					[−0.90]	[−0.22]
Dummy Q5 – change					−0.0034	−0.0024
					[−3.20]	[−2.17]
Return [−6, −1]	−0.0690	−0.0694	−0.0694	−0.0683	−0.0689	−0.0682
	[−9.77]	[−9.80]	[−9.17]	[−9.57]	[−9.60]	[−9.52]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted *R* squared (%)	3.17	3.13	3.17	3.17	3.14	3.18

spreads. The coefficient of the lowest quintile dummy is positive, albeit not significant. The coefficient for the highest change quintile dummy is significantly negative. The last column includes quintile dummies based on both volatility spread level and change quintiles. The results are similar to the those in the fourth and fifth columns. Stocks with relatively expensive put (call) options and stocks that experience the largest increases (decreases) in their volatility spreads earn significantly negative (positive) abnormal returns.

In all the regression specifications, one-week stock returns preceeding the earnings announcements have a significantly negative relationship with the announcement returns indicating the importance of short-term reversals in the sample. However, this does not alter the result that volatility spreads predict earnings announcement returns.

4.2. The role of information asymmetry and stock liquidity

In the quintile analyses, it was documented that the predictability of announcement returns by volatility spreads is stronger for stocks that are less liquid and have a higher probability of informed trading. In this subsection, these hypotheses are tested using panel regressions of announcement returns on volatility spread signals and interactions of these signals with PIN or liquidity dummies. Each regression in Table 8 includes contemporaneous and lagged firm characteristics and lagged weekly stock returns as control variables. Two-day announcement returns start accruing from the opening of the earnings announcement date and *t*-statistics are based on robust standard errors clustered by firm.

Table 8
Panel regressions: information asymmetry and stock liquidity. This table presents results for panel regressions of earnings announcement returns on various volatility spread signals or their interactions with quintile dummies formed based on either PIN (probability of informed trading) or Amihud (2002) illiquidity ratio. Stocks are sorted based on their PIN values or illiquidity ratios into quintiles each month. PIN low dummy (PIN high dummy) equals one for stocks with the lowest (highest) PIN values and zero otherwise. Liquidity high dummy (liquidity low dummy) equals one for stocks with the lowest (highest) Amihud illiquidity ratios and zero otherwise. First and third columns include volatility spread levels on the pre-announcement day and second and fourth columns include volatility spread changes during the pre-announcement week in the specification. In the first two columns, the volatility spread signals are interacted with PIN low dummy and PIN high dummy. In the last two columns, the volatility spread signals are interacted with liquidity high dummy and liquidity low dummy. The announcement returns accrue from the opening of the earnings announcement day to the closing of the next day. All specifications include contemporaneous and lagged values of market beta calculated from daily returns over the past twelve months, firm size as measured by the market value of equity, book-to-market ratio, one-month return in the pre-announcement period and skewness measured from daily returns over the prior year as control variables. The stock returns during the pre-announcement week are also controlled for in each specification. The *t*-statistics are based on robust standard errors clustered by firm.

	1	2	3	4
Intercept	0.0023	0.0019	0.0023	0.0019
	[6.06]	[5.26]	[5.98]	[5.25]
Level of volatility spread	−0.0346		−0.0336	
	[−4.27]		[−4.06]	
Change of volatility spread		−0.0156		−0.0229
		[−2.07]		[−2.89]
PIN low dummy interaction	0.0198	0.0160		
	[2.75]	[2.60]		
PIN high dummy interaction	−0.0152	−0.0076		
	[−2.28]	[−1.97]		
Liquidity high dummy interaction			0.0034	0.0203
			[0.75]	[2.83]
Liquidity low dummy interaction			−0.0098	−0.0082
			[−1.88]	[−1.33]
Return [−6, −1]	−0.0688	−0.0694	−0.0689	−0.0693
	[−9.75]	[−9.81]	[−9.77]	[−9.81]
Control variables	Yes	Yes	Yes	Yes
Adjusted R squared	3.17%	3.13%	3.17%	3.13%
Wald statistic *p*-value	0.0095	0.0103	0.0490	0.0271

The first two regressions in Table 8 investigate whether information asymmetry has an impact on the relationship between volatility spreads and announcement returns. Two dummy variables associated with PIN are created. "PIN low dummy" equals one for stocks that are in the lowest probability of informed trading quintile each month and zero otherwise. Similarly, "PIN high dummy" equals one for stocks that are in the highest probability of informed trading quintile each month and zero otherwise. These dummies are interacted with the levels of volatility spreads in column 1 and the changes in volatility spreads in column 2. Then, these interaction terms are included in the regressions along with the control variables and the levels of and changes in volatility spreads. Similar to Table 7, both the level of and the change in volatility spreads have significantly negative coefficients. More importantly, the coefficient associated with PIN low dummy interaction is significantly positive whereas the coefficient associated with PIN high dummy interaction is significantly negative. The Wald statistic rejects the hypothesis that the coefficients of the two interaction terms are equal. These results suggest that there is stronger announcement return predictability when the underlying stocks have more information asymmetry.

The same regressions are repeated after replacing the PIN quintile dummy interactions with the liquidity quintile dummy interactions. The results are presented in the last two columns of Table 8. As before, both the level of and the change in volatility spreads have significantly negative coefficients. Liquidity high dummy interactions have positive coefficients which suggests that the degree of predictability is less for stocks with higher liquidity. In contrast, the predictability of announcement returns is stronger for stocks with lower liquidity as suggested by the negative coefficients of liquidity low dummy interactions. Although the coefficients of the interaction variables are not significantly different from zero with the exception of the liquidity high dummy interaction in the change of volatility spread regression, the Wald statistics reject the equality of the low and high liquidity dummy interaction coefficients. These results highlight the importance of stock liquidity for the predictability of earnings announcement returns.

5. Conclusion

This study conjectures that if volatility spreads are driven by the trading activities of informed traders, then the predictability of equity returns by volatility spreads should be stronger around significant information releases. For this purpose, the study focuses on earnings announcements. Volatility spreads are defined as the weighted average differences of implied volatilities between strike price and expiration date matched put and call options. The demand for an option affects its expensiveness measured by its implied volatility and the definition of volatility spread used in this study captures such price pressures in the option market. Stocks with relatively expensive call options earn significantly higher returns compared to stocks with relatively expensive put options during a two-day announcement window. The abnormal return difference between stocks with both a low level and large decrease of volatility spreads and stocks with both a high level and large increase of volatility spreads is more than 1.5% during a two-day earnings announcement window.

The study presents several pieces of evidence arguing that predictability of announcement returns by volatility spreads is due to the existence of informed traders in the option market. First, coupled with the findings of Cremers and Weinbaum (2010), the

stronger predictability of equity returns during earnings announcement periods indicates the importance of conditioning on information events. Second, stocks with relatively expensive call options earn significantly positive abnormal returns during the announcement window which rules out short sales restrictions as the sole explanation of the results. Finally, the degree of announcement return predictability is shown to be stronger when informed investors are more likely to trade in the option markets. Specifically, the degree of predictability is higher when volatility spreads are measured using more liquid options, liquidity of the underlying equities is low and the information environment is more asymmetric.

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