Where Do Informed Traders Trade First? Option Trading Activity, News Releases, and Stock Return Predictability

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Abstract

We examine patterns of option trading activity around news announcements. Combining a database of option volume by trade type with a database of news releases, we find that option trading activity is unusually high both immediately before news days and on news days. As option volume on both days is a stronger predictor of future stock returns than option volume on other days, the trading advantage of informed option traders stems from their ability to analyze publicly available information as well as anticipate upcoming news events. Our main contribution is to show that where informed option traders trade depends on whether news releases are anticipated. We show theoretically that, when no news is scheduled to be released, informed traders prefer long option positions to short option positions and that the opposite is true ahead of scheduled news releases. Consistent with this, we find that purchases of options predict returns on news days and ahead of unscheduled events, but not before scheduled events, and sales of options are informative only ahead of scheduled news releases.

Keywords: option trading, news releases, informed investors, information processing, asymmetric information.

JEL Classifications: G12, G14.

1. Introduction

The days surrounding public news releases provide fertile grounds for skilled investors to trade. Prior to information being made public, traders with possibly private information can profit by trading in anticipation of an upcoming announcement. In addition, news releases can exacerbate information asymmetry: if some market participants have an advantage in interpreting the newly released information, they can profit from their superior information processing ability by trading after the news is announced.

Informed investors, and those who think they are informed, can choose to trade on their information in the option market or in the market for the underlying stock. Economic theory suggests that where they ultimately choose to trade is a function of the relative costs and benefits of trading in either venue (e.g., Easley, O'Hara and Srinivas, 1998). Several recent papers empirically establish the presence of informed trading in the option market. For example, Pan and Poteshman (2006) show that signed option trading volume contains information about future stock prices, indicating that some option traders truly are informed investors. However, there is little research that directly links option trading activity to news events. We fill this gap and provide new evidence on where and how informed traders trade. We also investigate the extent to which the information advantage of option traders varies in proximity to news events, thereby shedding new light on the source of their trading advantage.

To examine patterns of option trading activity around news announcements, we combine a comprehensive archive of news releases with a database of option volume initiated by either buyers or sellers to either open new positions or to close existing positions. Our main findings are easily summarized. First, we begin our analysis by considering the raw option-to-stock trading volume ratio of Roll, Schwartz and Subrahmanyam (2010). Option traders are more active than other market participants both immediately before and immediately after news releases. Separately considering call and put option volume initiated by buyers to open new positions and also distinguishing between events that turn out to be *ex post* positive and those that are *ex post* negative, we document that while there is anticipation (i.e., some option traders are truly informed

in that they trade in the direction of the upcoming announcement), a large volume of option trading to open new positions is initiated after news is made public.[1]

Second, given that option traders tend to trade more actively both before and after news events, we investigate whether news releases represent profitable trading opportunities for them. Pan and Poteshman (2006) show that option traders who initiate new positions on average have significant trading skills, as they find strong evidence that, on average, put-call open buy trading volume ratios predict underlying stock returns.[2] We likewise find that signed option trading volume contains information about future stock prices, but show that this effect is particularly strong around news announcements. While news days and the preceding days account for only 12.6% of the days in our sample, they account for over 38% of the overall predictability associated with open buy option trading volume.

Moreover, we shed further light on the source of the skill of these option traders. If the trading advantage of option traders is due to their ability to anticipate information that has yet to be released, there should be stronger predictability of open buy ratios before news releases. Alternatively (though not opposed to their ability to anticipate), if option traders are skilled at processing the content of recently released information, we would expect greater predictability on news days. We show that the predictive power of open buy put-call ratios quadruples on days that precede a news day and doubles on news days. We thus find that option trading volume on both days is a stronger predictor of future stock returns than option volume on other days, which suggests that the trading advantage of option traders comes from their ability to analyze publicly available information as well as anticipate upcoming news events.

Third, we condition on whether the timing of a news release is known *ex ante*. We focus on earnings announcements, as these are significant and *ex ante* well publicized information events, the timing of which

[1] In our sample, open buy trading volume on news days is 1.52 times that on days preceding news days.
[2] Pan and Poteshman (2006) construct put-call ratios from option trading volume initiated by buyers to open new positions as open buy put volume divided by the sum of open buy put volume and open buy call volume.

is known well in advance.[3] Because earnings announcements are important scheduled information events, implied volatility increases prior to earnings announcements and then drops off sharply immediately thereafter (Dubinsky and Johannes (2006), Patell and Wolfson (1979, 1980)). This pattern reduces the profitability of trading strategies involving long option positions and increases the returns on strategies that short options.

In the sequential trade model of Easley, O'Hara and Srinivas (1998), informed investors choose to trade in stocks or options by comparing the costs and benefits of trading in either venue. We use an extension of the Black-Scholes (1973) model, augmented with jumps on scheduled event dates, as in Dubinsky and Johannes (2006), to compare the profitability of long and short option strategies. In the absence of a scheduled news event, for a truly informed trader, a long option strategy produces higher returns, provided there is a large move in the stock price. However, when news is scheduled to be released, the drop in implied volatility on the scheduled event date affects option prices negatively. This reduces the return on long option positions and increases the return on short positions, thus rendering the short option strategy more profitable. Consequently, we would not expect informed investors to trade in options ahead of scheduled news announcements, except through short positions. For example, ahead of scheduled news that they expect to be positive, we would expect investors to sell puts rather than buy calls. However, ahead of unscheduled news releases, as well as on the news day itself, we would expect that informed investors prefer long option positions.

To test these hypotheses, we compare the predictive ability of both open buy and open sell option volume ratios. We condition on whether or not the event is scheduled and consider separately the predictability of the two signed option volume ratios before and after news releases. Consistent with the reduced profitability of long option positions ahead of scheduled news releases, our results indicate that open buy ratios are strong predictors of future stock returns on news days and ahead of unscheduled events, but not before

[3] Both the *Wall Street Journal* and Yahoo! Finance provide earnings calendars for public US firms. Missed earnings dates are rare, especially for optionable stocks, which tend to be large. For example, in a sample of 50 large firms, Dubinsky and Johannes (2006) report no instances of missed earnings dates between 1996 and 2002.

scheduled events. Strikingly, open sell ratios contain information about future stock prices only ahead of scheduled news releases. Roll, Schwartz and Subrahmanyam (2010) construct unsigned option-to-stock trading volume ratios and find that these ratios are higher around earnings announcements. We likewise find a spike ahead of earnings announcements using signed option volume ratios, but we find that open buy volume is largely uninformed while open sell volume is on average informed, as we would expect from the dynamics of implied volatility around earnings announcements.

Fourth and finally, because we find that the trading advantage of option traders comes from their ability to analyze publicly available information as well as their ability to anticipate the information in upcoming news events, we consider two extensions of our basic results that shed further light on the nature of the information advantage of option traders on both news days and on the preceding days. In the first extension, we investigate the source of the information advantage of option traders ahead of news releases, which is likely to be driven by private information, by considering the interaction between option trading and insider trading, a proxy for the existence of private information about a stock (Purnanandam and Seyhun (2011)). Consistent with our earlier results, a strategy that uses both the open buy option volume signal and the insider trading signal earns significant returns ahead of unscheduled news events but not before scheduled news events. Similarly, a strategy that uses the open sell option signal in conjunction with the insider trading signal earns significant returns ahead of scheduled news events but not before unscheduled news events. We further corroborate these findings by considering the interaction between open-buy and open-sell put-call ratios and put-call implied volatility spreads, another proxy for the availability of private information (e.g., Bali and Hovakimian (2009) and Cremers and Weinbaum (2010)).

In the second extension, we try to better understand the nature of the trading on news days, which is likely to be driven by superior information processing skills. In particular, we ask whether option traders are able to identify underreaction or overreaction (or both) on news days. We find that option traders' information processing ability stems primarily from their ability to identify underreaction to news: their trades on news

days are only informative about future stock prices when they buy call options on stocks that have experienced positive news events and when they buy put options on stocks that have experienced negative news events, while otherwise their trades are on average uninformative.

Our results are most closely related to the literature on information discovery in option markets. Several papers establish that various measures of informed option trading predict future returns on the underlying stocks. Pan and Poteshman (2006) find strong evidence of predictability using open buy option volume ratios. Other papers find evidence of predictability using indirect proxies for informed trading that are based on option prices. For example, Bali and Hovakimian (2009) and Cremers and Weinbaum (2010) show that volatility spreads, defined as the difference between call and put implied volatilities, predict stock returns. Similarly, Xing, Zhang and Zhao (2010) find that option implied volatility skews can predict future returns on the underlying stocks.[4]

Such evidence of stock return predictability does not speak to the way in which option traders generate their information advantage over other traders. One interpretation of the predictability is that some option traders are privately informed and trade before information is publicly released. An alternative explanation is that option traders are particularly skilled at analyzing information once it is made public. Jin, Livnat and Zhang (2012) show that the predictive ability of volatility spreads and implied volatility skews is greater before three specific events (earnings announcements, client and product announcements, and days with large stock price movements). They find that the degree of predictability is higher before earnings announcements (which are scheduled) than before key product announcements (largely unscheduled), which is difficult to reconcile with the theoretical framework of Easley, O'Hara and Srinivas (1998). Their evidence regarding

[4] Other related work includes Kumar, Sarin and Shastri (1992), who find abnormal option returns in the 30 minutes preceding block trades in the underlying stock, and Cao, Chen and Griffin (2005), who find that higher pre-announcement call option volume predicts larger takeover premia. Chakravarty, Gullen, and Mayhew (2004) analyze equity and call option microstructure data and find that the contribution of the call option market to price discovery is about 17%. Johnson and So (2012) emphasize the role of informed trading in options when short selling is costly, however Li, Lin and Pearson (2015) find that the role of options in "providing leverage is at least as important as their role in ameliorating short-sale constraints."

the predictability after the events is mixed. In contrast, we consider all corporate news events, we use direct measures of trading activity (open buy and open sell ratios), and we find strong results that are consistent with theory. Chan, Ge and Lin (2015) find evidence that volatility spreads and implied volatility skews predict acquirer announcement returns.[5] Another related paper is Lin, Lu and Driessen (2012), who show that volatility spreads and implied volatility skews predict three types of events (earnings announcements, analysis recommendations and analyst forecast revisions) and also find that the predictability of the option based measures for future returns is greater ahead of these events. Our empirical design considers both the news day and the preceding day, distinguishes between scheduled and unscheduled events, uses signed option volume, and takes into account all news releases. We find strong evidence that the information advantage of option traders comes from their ability to analyze publicly available information as well as their ability to anticipate upcoming news events. This contributes to both the literature on informed trading in options and to the policy debate, given that commentators in the popular press repeatedly emphasize that options are a vehicle of insider trading.

The remainder of this paper is organized as follows. Section 2 reviews the implications of the theoretical models guiding our empirical work and describes our data. Section 3 presents our results on option trading activity around news releases and the source of the information advantage of option traders. Section 4 distinguishes between scheduled and unscheduled events to analyze how option traders optimally trade on their information. Section 5 shows that our results are robust to using pool panel regressions that include a battery of control variables, including controls for reversal (e.g., Lo and MacKinlay (1990)) and liquidity (e.g., Chordia and Swaminathan (2000) and Gervais, Kaniel, and Mingelgrin (2001)). It also considers two extensions of our basic results to better understand the nature of the information advantage of option traders on both news days and on the preceding days. We conclude in Section 6.

[5] Augustin, Brenner and Subrahmanyam (2014) find evidence of informed option trading activity prior to mergers and acquisition announcements and Lowry and Zhu (2015) find evidence of informed option trading by advisor banks ahead of client firm mergers.

2. Informed Trading and News Announcements

This section reviews the main implications of the theoretical models that guide our empirical work and describes our data.

2.1 Theoretical Background

2.1.1 Models of Informed Trade

Theoretical asymmetric information models have mixed predictions regarding news announcements. On the one hand, most traditional models suggest that news releases reduce information asymmetry, e.g., Glosten and Milgrom (1985). These models typically feature informed investors who are endowed with private information as well as uninformed noise traders. Prior to news releases, market makers reduce liquidity because the probability of trading against an informed investor is large. Once news is released, the asymmetry of information disappears. If option traders are informed, these models would suggest that they would trade more, and their trades would be more informative, prior to significant news releases.

On the other hand, Kim and Verrecchia (1994) suggest that news releases can increase information asymmetry if some market participants have an advantage over others in interpreting news announcements. For example, earnings announcements often involve detailed disclosures and forward-looking statements, making heterogeneity across investors in their ability to decipher such releases likely. Under this view, if option traders are informed, they should trade more, and their trades should be more informative, on days on which significant news is released.

The sequential trade model of Easley, O'Hara, and Srinivas (1998) introduces trading in both options and the underlying stocks; it also features uninformed and informed investors. Liquidity traders participate in both markets for exogenous reasons and informed investors optimally choose whether to trade in the equity market, the options market, or both. Easley, O'Hara, and Srinivas (1998) derive a specific condition under which informed trading takes place in the options market. Where traders ultimately choose to trade is a function of the relative costs and benefits of trading in either venue.

Besides determining whether to trade in the option market, the stock market, or both, traders must decide *how* to design their option trades. Specifically, informed traders who are privy to a positive signal can trade in options by buying a call or selling a put; similarly, traders with negative information can buy a put or sell a call. It turns out that whether a long (i.e., buying a call upon a positive signal and buying a put upon a negative signal) or a short (i.e., selling a put upon a positive signal and selling a call upon a negative signal) option trading strategy is optimal depends on whether the news event is scheduled, as we now discuss.

2.1.2 Scheduled and Unscheduled Announcements

Most of the theoretical literature does not make an explicit distinction between scheduled and unscheduled news events. An important exception is the model in Kim and Verrecchia (1991), in which investors endogenously produce private information prior to news releases so as to trade on the information after the release. With informed traders possibly trading in both the stock and the option market, the distinction between scheduled and unscheduled news events becomes even more important because the returns of an option trading strategy can be different across these two types of events.

Empirically, it is well known that implied volatility increases prior to earnings announcements and then drops off sharply immediately thereafter (e.g., Dubinsky and Johannes (2006), Patell and Wolfson (1979, 1980)). Dubinsky and Johannes (2006) introduce a model that explains this pattern by augmenting the Black-Scholes (1973) option pricing model with randomly-sized but deterministically-timed jumps that occur on the scheduled event date. Specifically, they assume that the stock price S_t at time t follows the process

$$dS_t = S_t r dt + S_t \sigma dW_t + d\big(S_{\tau-}(e^Z - 1)\big),$$

$$Z = -\frac{1}{2}(\sigma^Q)^2 + (\sigma^Q)\epsilon,$$

where σ is the usual diffusive volatility, W_t is a Q-Brownian motion, Q is an equivalent martingale measure, and ε is distributed as a standard normal under Q. There is a single scheduled news announcement at time

$\tau < T$ at which point the stock price jumps. While the timing of the jump is known, its size is not: the size of the jump is log-normally distributed with volatility σ^Q.[6]

Under these assumptions, Dubinsky and Johannes (2006) show that the value at time *t* of a European option expiring at time $T > t$ is given by the usual Black-Scholes (1973) formula except that the volatility σ_t to be used in pricing the option is given by $\sigma_t^2 = \sigma^2 + \frac{1}{T-t}(\sigma^Q)^2$ before τ and $\sigma_t^2 = \sigma^2$ after. This simple model thus captures both the empirical observation that volatility tends to increase before earnings announcements, and that there is a sharp decrease in volatility after earnings announcements.

The Dubinsky and Johannes (2006) model can be used to understand how the returns on long and short option trading strategies vary depending on whether news is scheduled to be released before the options expire. In particular, we can use their model to compare and contrast the two types of strategies with and without scheduled events. Panel A of Figure 1 shows the one-day return on buying a call and selling a put as a function of the return on the underlying asset when no news is scheduled to be released during the life of the option, i.e., in the standard Black-Scholes (1973) model.[7] For a trader who is truly informed, the long call strategy, which has positive gamma, dominates the short put strategy, which has negative gamma. For such a trader, the long call strategy produces higher returns due to the positive gamma, provided there is a sufficiently large move in the stock price. Panel B shows the corresponding return when news is scheduled to be released the next day.[8] The drop in implied volatility on the scheduled event date affects both call options and put options negatively due to their positive vega; this reduces the return on the long call and increases the return on the short put, dominating the gamma effect and rendering the short put strategy more profitable.

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[6] Dubinsky and Johannes (2006) consider several extensions of this basic model, including more complex jump distributions, multiple jumps, and stochastic volatility as in Heston (1993). We do not consider these extensions because the simple Black-Scholes (1973) model augmented with deterministic jumps appropriately captures the main differences between long and short option positions in the presence of scheduled and unscheduled news announcements.

[7] The options are at the money, have one month to expiration and diffusive volatility of 30%. For short positions we show the dollar profit and loss divided by the initial value of the option.

[8] Based on the empirical results in Dubinsky and Johannes (2006), we assume a jump size volatility of 10%.

This analysis suggests that, if volatility is expected to remain constant around an event, then an informed investor with a positive signal will prefer buying a call to selling a put due to the positive gamma of the call. Similarly, an informed investor with a negative signal would prefer buying a put to selling a call. However, if the event is scheduled and implied volatility is thus expected to drop when the news is made public, then the opposite is true: trading strategies that involve short option positions are generally more profitable. Thus we would not expect informed investors to trade in options ahead of scheduled news announcements, except through short positions. However, ahead of unscheduled news releases, as well as on news days, informed investors should prefer long option positions.

2.2 Data

We employ two main databases. The first database contains information on trading volume initiated by buyers to open new options positions; the second contains a record of all news released on the Reuters data feed.

2.2.1 Option Data

Our options data come from the International Securities Exchange (ISE). The dataset covers all ISE listed options and consists of daily non-market-maker trading volume for our sample period of January 2003 to February 2009. For each option, daily trading volume is broken down into four categories: open buy (traders buying options to open new positions), open sell (traders selling options to open new positions), close buy (traders buying options to close existing positions) and close sell (traders selling options to close existing positions). The trading volume is further classified by trader type (customer or firm). Although the ISE data are similar to the signed option volume data used in Pan and Poteshman (2006), there are two main differences. First, the Pan and Poteshman (2006) dataset covers CBOE listed options, whereas our data include transactions that were executed at the ISE. While this represents only a subset of the total volume of trade in listed options, the ISE is the most active options exchange over our sample period, with a market share of approximately 30% (Muravyev, 2013). Second, and more importantly, the data in Pan and Poteshman

(2006), which cover the years 1990 through 2001, were not released to the public until 2006. In contrast, the ISE data are public. We thus expect to find less predictability of signed option trading volume for future stock returns relative to the results in Pan and Poteshman (2006).

We augment the open-buy trading volume data with option quote and implied volatility data from OptionMetrics, which provides end-of-day bid and ask quotes, open interest, volume, and implied volatility on all exchange-traded options. For options on individual stocks, which are American, OptionMetrics computes implied volatilities using a binomial tree, taking into account discrete dividend payments and the possibility of early exercise, and using historical LIBOR/Eurodollar rates for interest rate inputs. We merge the combined option data set with the Center for Research in Security Prices (CRSP) daily stock data following Duarte, Lou, and Sadka (2005).

2.2.2 News Archive

Our news data originate from the Reuters NewsScope Sentiment Engine (RNSE), a comprehensive database of all news releases on the Reuters data feed.[9] For each news item the dataset contains a time stamp, measures of tone, relevance, novelty, and potentially several topic codes. The tone of the article consists of estimates of three probabilities: the probability that the tone of the story is positive, negative and neutral. These probabilities are estimated using tools and algorithms from computational linguistics. The relevance score ranges from 0 to 1; it provides an assessment of how specific the news is to a given firm (e.g., a score of 0.5 corresponds to two firms featuring equally prominently in a release). The novelty variable provides a count of the number of similar stories that have appeared on the Reuters screen over the preceding 24 hours. The topic code describes the topic or topics of each news article and is provided by the author of the article.

[9] Several recent papers use this database. Among others, Hendershott, Livdan and Schurhoff (2015) combine Reuters data with data on institutional trading and find that institutional investors are informed, Li, Lin and Pearson (2015) use Reuters data to study analyst revisions, and Scherbina and Schlusche (2014) use the data to identify economically linked stocks.

Even though the RNSE database contains measures of the tone of each story, we follow Engelberg, Reed and Ringgenberg (2012) and use the announcement day return on the day of a news event to sign the content of news. While the measure of 'tone' derived by Reuters provides information about the content of a news article, it does not reflect market participants' prior expectations. For example, a news article could describe rather bad news, but if the market was expecting even worse news, then the negative news story could actually result in a positive stock market reaction. We therefore likewise use announcement day returns to classify events as either good or bad news. Our results remain qualitatively unchanged if we instead use the Reuters news tone measure to classify articles.

In order to merge the news data with the stock and options data, the date associated with each news item is established using as a cutoff the NYSE closing time of 4:00pm Eastern: if news is released before the market closes, we assign the current trading day to the release, otherwise we assign the next trading day.[10]

2.2.3 Merged Data

Table 1 presents descriptive statistics on the merged data. It shows information on firm-level trading days organized in four groups. These groups are (i) days without news announcements (Panel A), (ii) days with news announcements (Panel B), (iii) days with unscheduled news announcements (Panel C) and (iv) days with scheduled news announcements (Panel D). Earnings announcements are significant news events that are scheduled and widely anticipated, i.e., their timing is known ex ante. While the timing of other types of news events is sometimes anticipated also, we prefer to be cautious and treat only earning announcements as scheduled and all other news events as unscheduled.

For each group, we present summary statistics on daily trading volume broken down into the four categories described above, namely call open buy volume, call open sell volume, put open buy volume and put open sell volume, all measured in numbers of contracts traded. For example, an investor who wishes to place a

[10] In our sample, 60.2% of news announcements are made afterhours. For those news announcements when markets are open, the average time of an announcement is just after 1:00pm Eastern.

bullish trade on a stock may sell put options; having no prior position and entering this trade would be classified as a put open sell volume trade. Panel A also presents statistics for the number of no news firms per day and no news days per firm. Similarly, in Panel B we present statistics for the number of news firms per day and news days per firm. Several interesting observations emerge from these data. Trading volume is extremely volatile in all four panels and for each of the four types of option trades. The mean trading volume is much larger than the median volume, which indicates that the distribution of option trading volume is skewed on both news days and no news days. Trading volume on news days is significantly larger than on other days, which suggests that option traders are particularly active around news releases, a point which we investigate in greater detail below.

3. Option Trading Activity around News Announcements

This section presents our main results on option trading activity around news releases and investigates the source of the information advantage of option traders. We begin by asking whether option traders respond to news and whether they do so before other market participants. We find that, relative to other traders, option traders tend to trade both ahead of news and immediately after news is released. Some of this trading appears to be informed. Next, we investigate whether option trades are more informative around news events and find strong evidence that this is the case.

3.1 How do Option Traders Behave around News Announcements?

To examine patterns of option trading activity around news announcements, we begin by considering the raw option-to-stock trading volume ratio of Roll, Schwartz and Subrahmanyam (2010). Figure 2 depicts option trading volume, underlying stock trading volume, and the ratio of option volume to underlying stock trading volume around news events. We compute each measure daily from 5 days before to 5 days after news releases.

We find that, relative to other traders, option traders are particularly active both ahead of news and immediately after news is released: there is a significant increase in both stock and option volume on news days

and on the days surrounding news days. Moreover, the ratio of option volume to underlying stock trading volume increases in the days leading up to news releases, peaks on the news day, and then abruptly drops off. Of course, the fact that we observe increased option trading ahead of events does not imply trades are informed: these trades could instead reflect investors' incorrect but strong beliefs, i.e., they could originate from uninformed agents convinced they have information. Therefore, we next ask whether option traders correctly anticipate news.

Figure 3 presents, separately for positive and negative news events, median values of call open buy volume in Panel A, put open buy volume in Panel B, and, in Panel C, the open buy put-call volume ratio, which is the ratio of put open buy volume to total open buy volume, defined as in Pan and Poteshman (2006) as

$$OB_{it} = \frac{PB_{it}}{PB_{it} + CB_{it}},$$

where, on date t and for stock i, PS_{it} and CS_{it} are the number of put and call contracts purchased by non-market makers to open new positions. We classify news days in the top quintile of market adjusted returns as positive and news days in the bottom quintile of market adjusted returns as negative. Several observations can be drawn from Figure 3. First, much option trading occurs after news is released rather than before: all three panels indicate that option trading activity peaks on the news event day rather than on the preceding day. This is important because it suggests that the ability of option traders to analyze publicly available information when it is released is central to their information advantage. Second, Panels A and B show that much of the option trading volume that occurs prior to news releases seems uninformed: both call and put open buy volumes increase before both good and bad news. Nevertheless, the two panels suggest that there is some informed trading, inasmuch as call open buy volume increases more before good news than before bad news, and put open buy volume increases more before bad news than before good news. More importantly, Panel C shows that put open buy volume ratios are high before negative news events and low before positive news events, which is suggestive of informed trading. Next, we formally test whether these differences are statistically significant.

We regress call open buy volume, put open buy volume, and the put open buy volume ratio on a pair of indicator variables that take the value of one if a positive or negative news event occurs, and zero otherwise. To control for the response of option traders to past underlying stock returns (e.g., Lakonishok, Lee, Pearson and Poteshman (2007)), we include two lags of underlying returns. To shed light on the timing of option trades around news events, we run seven different specifications by varying the timing of the dependent variable relative to the news event. Specifically, we run seven Fama-MacBeth (1973) regressions of the form

$$OptionActivity_{it} = \beta_1\left(Ret_{i,t-1}\right) + \beta_2\left(Ret_{i,t-2}\right) + \beta_3\left(GoodNews_{i,j}\right) + \beta_4\left(BadNews_{i,j}\right) + \epsilon,$$

where, for stock *i* on day *t*, $OptionActivity_{it}$ denotes the relative call open buy volume, relative put open buy volume, or put open buy volume ratio, $Ret_{i,t}$ is the return of stock *i* on day *t*, $GoodNews_{i,j}$ and $BadNews_{i,j}$ are the two good and bad news binary variables, and we vary *j* from *t*-3 to *t*+3.

Table 2 presents the results. Panels A and B report results for call and put open buy trading volume and Panel C reports the results for put open buy volume ratios. The results in Table 2 are consistent with those in Figure 3. Panels A and B show that option trading activity peaks on news days. On the day before news is released, we find heightened call and put buying trading activity prior to both good and bad news events. Call option open buy volume increases relatively more before good news and put option buy volume increases more before bad news, and while this is suggestive of informed trading, the differences are not statistically significant. However, Panel C shows that put open buy volume ratios are significantly higher before negative news events, which is consistent with the presence of informed investors trading in the option market prior to news announcements.

Overall, the evidence suggests that option traders trade both ahead of news and after news is released, as one would expect if the previously documented information advantage of option traders comes from their ability to analyze publicly available information as well as their ability to anticipate upcoming news.

3.2 How are Option Traders Informed?

Given our finding that option traders are particularly active on news days and on the preceding days, this section investigates whether news releases represent profitable opportunities for option traders. Pan and Poteshman (2006) show that option traders have a significant information advantage over other investors: they find strong evidence that put-call open buy volume ratios predict underlying stock returns. We ask whether this predictability varies around news events, thereby shedding light on whether option traders' information advantage stems from their ability to interpret publicly available information or from having access to private information.

We begin by replicating the main result in Pan and Poteshman (2006) using portfolio sorts. Every day, we sort stocks into quintiles based upon their open buy put-call ratios, form equally-weighted portfolios, and compute risk-adjusted returns on each portfolio. Like Pan and Poteshman (2006), when constructing the risk-adjusted returns, we follow the standard approach of using a four-factor model that includes market, size, value, and momentum factors. The economic motivation for using risk-adjusted returns rather than raw returns is to remove the systematic component from stock returns and focus our tests on the information content of option trading for the idiosyncratic component of returns.[11]

For each of the five days following portfolio formation, Panel A in Table 3 reports risk-adjusted returns on the quintile portfolios and on a long-short hedge portfolio that buys stocks with high open buy put-call ratios and sells stocks with low open buy put-call ratios. Several results emerge from this analysis. The next-day risk-adjusted return on the long-short hedge portfolio is -0.134% with a *t*-statistic of -9.82. The long-short portfolio continues to earn negative returns each day for five days following portfolio formation, resulting in an overall return of -0.27% over five days. The average returns decrease monotonically as one goes from the bottom quintile (low open buy put-call ratios) to the top quintile (high open buy put-call ratios). Overall, these results closely resemble those in Pan and Poteshman (2006), although economically

[11] Our results are insensitive to using raw rather than risk-adjusted returns.

the predicted returns that we find are smaller in magnitude, consistent with the fact that our trading volume data are publicly available to market participants, whereas the open buy and sell data in Pan and Poteshman (2006) were not publicly available during their sample period. Thus the results in Panel A of Table 3 confirm the existing finding that option traders are informed.

We next ask whether this information advantage is concentrated on news days. To test for this, we continue to form quintile portfolios but use only open buy put-call ratios that are measured around news releases. Panel B in Table 3 reports risk-adjusted returns on the quintile portfolios and the long-short hedge portfolio formed on days preceding news days, Panel C presents results for news days, and Panel D shows differences between the returns on the long-short hedge portfolios on news days and days preceding news days versus all days.

The next-day risk-adjusted return on the long-short hedge portfolio that buys stocks with high open buy put-call ratios measured on the day before news days and sells stocks with low open buy put-call ratios measured on the day before news days is -0.583% with a *t*-statistic of -4.42. Comparing this to the corresponding unconditional hedge portfolio return in Panel A, the result is apparent: the predictive power of open buy put-call ratios more than quadruples on days before news days. Panel D shows that the difference is large economically and highly statistically significant.

The next-day risk-adjusted return on the long-short hedge portfolio formed based upon open buy put-call ratios measured on news days is -0.325% with a *t*-statistic of -4.96. Comparing this to the corresponding unconditional hedge portfolio return in Panel A reveals that the predictive power of open buy put-call ratios more than doubles on news days. The difference is again economically large and statistically significant.

We thus find that the information advantage of option traders comes from their ability to analyze publicly available information *as well as* their ability to anticipate upcoming news events. Option volume on both days is a significantly stronger predictor of future stock returns than option volume on other days.

4. How do Informed Option Traders Trade?

An option trader endowed with positive information about a stock can trade on the information by either buying calls or by selling puts. Similarly, an option trader with negative information about a stock can buy puts or sell calls. In this section, we distinguish between scheduled and unscheduled events, as we argue in Section 2.1 that this distinction is paramount in understanding whether an agent should optimally trade through long or short option positions.

4.1 Dynamics of Option Prices around News Releases

We condition on whether the timing of news releases is known *ex ante*, focusing on earnings announcements as significant scheduled information events. Because earnings announcements are significant scheduled information events, implied volatilities increase prior to earnings announcements and then drop off sharply immediately thereafter (Dubinsky and Johannes (2006), Patell and Wolfson (1979, 1980)). In Figure 4, we confirm this pattern in our sample by depicting changes in implied volatility for five days before to five days after news events separately for scheduled and unscheduled events. For scheduled events, implied volatility increases in the days leading up to news releases, peaking on the day before news is released.[12] Unscheduled events have a much smaller impact on implied volatility and thus option prices.

In Section 2.1, we used the Dubinsky and Johannes (2006) model to show that this pattern of increasing implied volatilities leading up to scheduled news events reduces the profitability of trading strategies that involve long option positions and increases the returns on strategies that short options. In the sequential trade model of Easley, O'Hara and Srinivas (1998), informed investors choose to trade in stocks or options by comparing the costs and benefits of trading in either venue. Thus, ahead of scheduled news announcements, we would not expect informed investors to trade in options, except through short positions. For

[12] In a recent paper, Xing and Zhang (2013) show that, in spite of this pattern, straddles earn large positive returns on earnings announcement days, which suggests that market participants tend to underestimate uncertainty on earnings dates.

example, ahead of scheduled news they expect to be positive, investors would rationally prefer selling puts to buying calls. However, ahead of unscheduled news releases, as well as on news days, informed investors would favor long option positions, which we would expect to be more profitable then.

To test whether informed option traders behave differently around scheduled and unscheduled information events, we compare the predictive ability of open buy and open sell put-call option volume ratios. We compute open-sell ratios as

$$OS_{it} = \frac{PS_{it}}{PS_{it} + CS_{it}},$$

where, on date *t* and for stock *i*, PS_{it} and CS_{it} are the number of put and call contracts sold by non-market makers to open new positions.

4.2 Empirical Results

We begin our analysis by employing portfolio sorts in which we condition on whether events are scheduled and consider separately the predictability of the two signed option volume ratios before and after news releases. Table 4 reports the evidence. Panel A shows the risk-adjusted returns on quintile portfolios and hedge portfolios formed on days before news days using either open buy or open sell put-call option ratios. On days before unscheduled news events, the long-short portfolio that buys stocks with high open buy put-call ratios and sells stocks with low open buy put-call ratios earns a next day adjusted return of -0.486% with a *t*-statistic of -3.84. However, on days before scheduled news events, the corresponding long-short portfolio earns a much smaller and statistically insignificant return of -0.099%.

Strikingly, the predictability based upon put open sell put-call ratios is exactly the reverse. On days before scheduled events, the long-short portfolio that buys stocks with high open sell put-call ratios and sells stocks with low open sell put-call ratios earns a next day adjusted return of 0.86% with a *t*-statistic of 2.27. But on days before unscheduled events, the corresponding long-short portfolio earns an insignificant 0.032%.

Panel B reveals consistent results for portfolios formed on news event dates. We find that open buy ratios are strong predictors of future stock returns on news days for both scheduled and unscheduled events and that open sell ratios are uninformative on both days. The evidence in Table 4 is consistent with informed option traders choosing how to optimally trade to take advantage of their information advantage.

Roll, Schwartz and Subrahmanyam (2010) construct unsigned option-to-stock-trading volume ratios using OptionMetrics volume data and find that these ratios are higher around earnings announcements. In Figure 5, we plot trading volume in stocks and options in the days surrounding news events, where we separately consider scheduled and unscheduled events, and positive and negative news. Panel A shows stock trading volume and Panels B and C show call and put open buy volumes. Consistent with Roll, Schwartz and Subrahmanyam (2010), we find a spike in option volume ahead of earnings announcements using signed option volume ratios. However, this open buy volume is largely uninformed, as we would expect from the dynamics of implied volatility around earnings announcements: call open buy volume is high before both good and bad earnings announcements and, similarly, put open buy volume is high before both good and bad earnings announcements.

Our results from portfolio sorts show that an option trader's decision to trade through long versus short option positions hinges crucially on whether or not the timing of the news event is known. In the next section, we show that this finding is robust to the use of firm level cross-sectional regressions.

5. Further Interpretation and Discussion

This section first investigates the extent to which signed option trading volume predicts returns using pool-panel regressions of stock returns on open buy and open sell put-call volume ratios and several control variables, including past returns (to control for short-term reversal) and proxies for liquidity. After showing that our results are robust to this alternative approach and to the controls, we consider two extensions to help us shed additional light on the nature of the information advantage of option traders on both news days and on the preceding days. First, to better understand trading on the preceding days, which is likely to be

driven by private information, we consider the interaction between option trading and both insider trading and implied volatility spreads, two proxies for the potential availability of such private information. Second, to better understand the nature of the trading on news days, which is likely to be driven by superior information processing skills, we ask whether option traders are able to identify underreaction or overreaction on news days.

5.1 Cross-Sectional Regressions

Our baseline robustness check employs pooled, cross-sectional panel regressions to examine the information content of open buy and open sell put-call volume ratios on news days and on preceding days.

This analysis is important for several reasons. First, it establishes the robustness of our earlier results based on portfolio sorts to an alternative specification. Second, it enables us to include several control variables, in addition to risk, which we control for by including size, book-to-market, and momentum factors in computing risk-adjusted returns. We follow Pan and Poteshman (2006) and include two liquidity controls (turnover and bid-ask spread) as well as the stock's own past weekly return. These are important because stock returns are known to be related to trading volume (e.g., Chordia and Swaminathan (2000) and Gervais, Kaniel, and Mingelgrin (2001)) and short-term reversal is a well-established phenomenon (e.g., Lo and Mackinlay (1990)). Third, the regressions allow us to decompose the predictability of stock returns by open buy and open sell put-call trading volume ratios and estimate the fraction of the overall predictability that is driven by news days and days that precede news days.

First, we begin our analysis by running regressions of the form

$$Ret_{i,t} = \alpha + \beta_1 OB_{i,t-1} + \beta_2 Turnover_{i,t-1} + \beta_3 Spread_{i,t-1} + \beta_4 Ret_{i,[t-5,t-1]} + \epsilon,$$

and

$$Ret_{i,t} = \alpha + \beta_1 OS_{i,t-1} + \beta_2 Turnover_{i,t-1} + \beta_3 Spread_{i,t-1} + \beta_4 Ret_{i,[t-5,t-1]} + \epsilon,$$

where, for stock i on day t, $Ret_{i,t}$ is the four-factor adjusted return, $OB_{i,t}$ is the open buy put-call volume ratio, $OS_{i,t}$ is the open sell put-call volume ratio, $Turnover_{i,t}$ and $Spread_{i,t}$, are, respectively, the underlying stock turnover and bid-ask spread, and $Ret_{i,[t-5,t-1]}$ is the return on stock i over the five day interval $[t-5,t-1]$.

Panel A in Table 5 shows the baseline regressions for all firm days. Consistent with Panel A in Table 3, the Pan and Poteshman (2006) result comes through strongly: the coefficient on put-call open buy ratio is negative and significant, which suggests high levels of put buying activity predict price decreases on the underlying stocks the next day, and confirms the known finding that option traders are informed. The coefficient on put-call open sell ratio is small in magnitude and statistically insignificant, indicating that sales of options do not predict returns unconditionally.

Second, given our earlier findings in Section 3, we examine whether the information advantage of option traders is concentrated on news days or on the preceding days. To investigate this, we estimate regressions in which option trading volume is measured on news days and, separately, on days that precede news days. Panel B in Table 5 presents these results. On days that precede news days, the coefficient on put-call open buy ratio is -0.659, on news days it is -0.254. Both estimates are highly statistically significant. Comparing these magnitudes to the coefficient on open buy ratio for all days of -0.149 reveals that the predictability quadruples on days that precede news days and nearly doubles on news days. Open sell put-call volume ratios remain insignificant in these regressions.

To estimate the fraction of the predictability that is driven by trading around news events, we follow the approach in Boehmer, Jones and Zhang (2012). News events constitute 6.28% of our sample and the overall predictive coefficient of put-call open buy trading volume ratios is 0.149, therefore the fraction of the predictability that is due to trading on news days and the preceding days is $(0.659 \times 6.28\% + 0.254 \times 6.28\%) / 0.149 = 38.45\%$. We thus find that, while news days and the preceding days account for only 12.6% of the days in our sample, they account for over 38% of the overall predictability associated with open buy option trading volume.

Third, given our findings in Section 4, we condition on whether events are scheduled so as to analyze whether option traders trade differently around scheduled versus unscheduled events. To investigate this, we estimate regressions in which option trading volume is measured on or before scheduled news days and, separately, on or before unscheduled news days. The results are in Panels C and D of Table 5. For unscheduled news days, we find strong predictability using open buy put-call ratios measured on both news days and on preceding days. On both days open sell put-call ratios are uninformative. On the other hand, for scheduled news days, we find strong predictability using open sell put-call ratios measured on days that precede news days but no predictability using open buy put-call ratios, and on news days open buy put-call ratios are highly informative while open sell put-call ratios are not.

These results are entirely consistent with those in Table 4 and confirm that informed option traders optimally choose how to trade to best take advantage of their information, in light of the fact that long option positions are generally more profitable for informed investors, except ahead of scheduled news events, because implied volatility increases in the days leading up to such events and drops thereafter.

5.2 Interactions with Measures of Private Information

In this section, we consider extensions of our basic results where we examine whether the predictability of option trading volume on days that precede news events increases when more private information is available about the stock. We focus this analysis on days that precede news days because trading ahead of news releases is more likely to be driven by private information. We consider two proxies for the potential availability of private information: insider trading and deviations from put-call parity. We first examine the interaction between option trading and insider trading and then consider the interaction of option trading and implied volatility spreads.

Insider trades constitute a well-established measure of private information about the future prospects of a firm (e.g., Seyhun (1986, 1992)). We follow Purnanandam and Seyhun (2011) and define net insider trading as the difference between the purchases and sales of stock by the directors and top executives of a firm over

a 30-day period extending from the 16th of the previous month to the 15th of the current month. We merge the insider trading data with the option trading data by using, for each option trading observation, the most recent net insider trading calculation that entirely precedes the option trade date. To test whether the ability of put-call open buy and open sell trading volume ratios to predict future returns is greater when more information is potentially available about a stock, we consider double sorts on open buy (or sell) ratios and net insider trades.

Panel A in Table 6 presents the next-day, four-factor adjusted returns on these double sorts, first for all events, then for scheduled and unscheduled events separately. The results on the left of the panel pertain to open buy put-call ratios and those on the right pertain to open sell put-call ratios. In all cases we measure option trading volume on days before news days, to focus the analysis on private information. The return in the lower right corner corresponds to a strategy that buys stocks with both positive option signals and positive insider trading signals and sells stocks with both negative option signals and negative insider trading signals. The main result is readily apparent: the returns based on both signals are large and statistically significant only when we expect option trades to be informed, i.e., for open buy volume before unscheduled events (return of 0.64% with a *t*-statistic of 2.37) and for open sell volume before scheduled events (return of 2.66% with a *t*-statistic of 3.66).

In light of these findings, we also interact open buy (and sell) put-call trading volume ratios with a measure of price pressure in the option market, namely call-put implied volatility spreads, defined as the difference in implied volatility between call and put options on the same underlying equity, and with the same strike price and the same expiration date. Following Cremers and Weinbaum (2010), we compute volatility spreads on day *t* and for stock *i* as

$$\begin{aligned} VS_{i,t} &= IV_{i,t}^{calls} - IV_{i,t}^{puts} \\ &= \sum_{j=1}^{N_{i,t}} w_{j,t}^{i} \left(IV_{j,t}^{i,call} - IV_{j,t}^{i,put} \right), \end{aligned}$$

where *j* refers to pairs of put and call options (and thus indexes both strike prices and maturities), the $w_{j,t}^{i}$

are open interest weights, there are $N_{i,t}$ valid pairs of options on stock i on day t, and $IV^{i}_{j,t}$ denotes Black-Scholes (1973) implied volatility (from OptionMetrics, which provides estimates adjusted for expected dividends and early exercise).

Cremers and Weinbaum (2010) show that implied volatility spreads predict future underlying stock returns and interpret volatility spreads as a proxy for price pressure in the option market stemming from informed option trading. As an additional test of whether the predictive power of put-call open buy (and sell) trading volume ratios is greater when more information is potentially available about a stock, we consider double sorts on open buy (or sell) ratios and volatility spreads.

Panel B in Table 6 has the results for these double sorts for all events and separately for scheduled and unscheduled events. We continue to measure open buy and open sell put-call option trading volume on the days before news days to focus on the private information aspect of option traders' information. Consistent with our earlier result for insider trading, we find that the returns based on both signals are large and statistically significant when we expect option trades to be informed, namely for open buy volume before unscheduled events and for open sell volume before scheduled events.

5.3 Information Processing on News Days

Our finding in Section 3 that option traders are skilled information processors leads us to consider more closely their trades on news days. To better understand how option traders trade on news days, we ask whether they generally trade in the direction of news releases or in the opposite direction. If option traders are contrarian traders, they trade by identifying stocks that have potentially overreacted to news, buying calls on stocks that have fallen in response to bad news or buying puts on stocks that have risen in response to good news. Another possibility is that option traders are better able to identify stocks that have underreacted to recent news. In this case, option traders would trade in the direction of news releases, buying call options on stocks that have gone up in response to good news and buying puts on stocks that have fallen in response to bad news. A third possibility is that option traders are able to identify both underreaction and

overreaction and earn significant returns on both types of trades.

To investigate this, we divide firm days according to whether the open buy ratio on the new day contradicts the nature of the news event. If a news event is classified as Good (Bad) news based on market-adjusted returns and the open buy ratio is not in the bottom (top) half of daily open buy ratios, the signal is considered contrarian. If a news event is classified as Good (Bad) news based on market-adjusted returns and the open buy ratio is in the bottom (top) half of daily ratios, the signal is considered agreeing. We then sort stocks into quintiles based on these agreeing and contrarian open buy volume ratios.[13]

Table 7 has the next-day, four-factor adjusted returns on these quintile portfolios, first for all events, then separately for scheduled and unscheduled events. The main result is that open buy put-call option trading volume is only informative when it is agreeing. This holds true for all events and for both the subset of unscheduled events and the subset of scheduled events. Thus option traders derive their information processing ability from the ability to identify underreaction to news. Their trades on news days are only informative about future stock prices when they buy relatively more call options on stocks that have experienced positive news events and when they buy relatively more put options on stocks that have experienced negative news events.

6. Conclusion

While much previous research shows that option traders are informed, relatively little is known about the source of this information advantage. In this paper, we fill this gap by asking how option traders become informed. We also examine *how* option traders trade on their information advantage. To do this, we combine a database of public news events in the U.S. with a database of option volume initiated by traders to open new positions.

[13] We do not consider open sell trading volume ratios in this analysis because we want to understand the manner in which informed option traders trade on news days and we know from our earlier results that sales of options are uninformative on news days.

We find that option traders are particularly active in the days surrounding public news releases: option trading activity is unusually high both immediately before news days and on news days. Next, we investigate whether news releases represent profitable trading opportunities for option traders, and find that they do. We find that option trading volume on both days is a stronger predictor of future stock returns than option volume on other days, which suggests that the trading advantage of option traders comes from their ability to analyze publicly available information as well as their ability to anticipate upcoming news events.

To understand *how* option traders trade on their information, we condition on whether the timing of a news release is known *ex ante*. Because earnings announcements are significant information events that are scheduled and widely anticipated, implied volatility increases prior to earnings announcements and then drops off sharply immediately thereafter (Dubinsky and Johannes (2006), Patell and Wolfson (1979, 1980)). We show that this pattern reduces the profitability of trading strategies that involve long option positions and increases the returns on strategies that short options. Therefore we expect informed investors to trade in options ahead of scheduled news announcements only through short positions. In contrast, ahead of unscheduled news events and on news days, informed investors would prefer long option positions, which are expected to be more profitable. We test these hypotheses by comparing the predictive ability of open buy and open sell put-call option volume ratios. We find that open buy ratios are strong predictors of future stock returns on news days and ahead of unscheduled events, but not before scheduled events. Open sell ratios contain information about future stock prices only ahead of scheduled news releases.

Because we find that the trading advantage of option traders comes from their ability to analyze publicly available information as well as their ability to anticipate upcoming news events, we further analyze their trades on both news days and on the preceding days. We find that the predictability of option trading volume on days that precede news events increases when more private information is potentially available about the stock. On news days, we show that option traders derive their information processing skills from an ability to identify underreaction to news: their trades on news days are only informative about future stock prices when they buy call options on stocks that have experienced positive news events and when they buy

put options on stocks that have experienced negative news events, otherwise their trades are uninformative.

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Table 1. Descriptive Statistics

This table presents descriptive statistics for firm days in four groups. These are firm days without news announcements (Panel A), firm days with news announcements (Panel B), firm days with unscheduled news announcements (Panel C) and firm days with scheduled news announcements. In all panels, statistics are presented for Call Open Buy Volume, Call Open Sell Volume, Put Open Buy Volume and Put Open Sell Volume (all presented in numbers of contracts). For example, if an investor has a bullish outlook on a stock, they might wish to sell put options, having no prior position and entering this trade would be classified as a Put Open Sell Volume trade. In Panel A we also present statistics for the number of No News Firms per Day and No News Days per Firm. Similarly, in Panel B we present statistics for the number of News Firms per day and News Days per Firm. For all variables, we show the sample size N, Mean, Standard Deviation, 25th Percentile, Median, and 75th percentile.

Panel A: No News	N	Mean	Standard Deviation	25 Percentile	Median	75th Percentile
Call Open Buy Volume	427,280	738	2,325	26	140	555
Call Open Sell Volume	427,280	630	2,033	26	121	472
Put Open Buy Volume	427,280	552	1,940	23	102	413
Put Open Sell Volume	427,280	483	1,707	23	91	337
No News Firms per Day		452	100	370	464	532
No News Days per Firm		248	259	43	137	394

Panel B: News	N	Mean	Standard Deviation	25 Percentile	Median	75th Percentile
Call Open Buy Volume	43,507	2,188	5,739	118	512	1,862
Call Open Sell Volume	43,507	1,779	4,566	100	416	1,514
Put Open Buy Volume	43,507	1,629	4,576	70	327	1,277
Put Open Sell Volume	43,507	1,407	3,995	65	277	1,079
News Firms per Day		46	15	34	45	56
News Days per Firm		25	39	3	11	30

Panel C: Unscheduled News	N	Mean	Standard Deviation	25 Percentile	Median	75th Percentile
Call Open Buy Volume	35,864	2,306	5,907	125	541	1,982
Call Open Sell Volume	35,864	1,878	4,694	105	441	1,621
Put Open Buy Volume	35,864	1,737	4,815	72	343	1,368
Put Open Sell Volume	35,864	1,489	4,167	66	286	1,142

Panel D: Scheduled News	N	Mean	Standard Deviation	25 Percentile	Median	75th Percentile
Call Open Buy Volume	7,643	1,631	4,831	96	396	1,339
Call Open Sell Volume	7,643	1,314	3,876	80	320	1,085
Put Open Buy Volume	7,643	1,125	3,177	62	259	964
Put Open Sell Volume	7,643	1,024	3,037	61	246	830

Table 2. Option Trading Activity Around News Releases

This table presents Fama-MacBeth (1973) regressions where the dependent variable is call open buy volume on the indicated day as a percentage of call open buy volume on day *t*-5 (Panel A), put open buy volume on the indicated day as a percentage of put open buy volume on day *t*-5 (Panel B), put-call open buy ratio, calculated as put open buy volume as a percentage of total open buy volume (Panel C). Day *t* is the day of a news event. Independent variables are underlying stock returns on each of the two days prior to the date of dependent variable observation and a pair of binary variables indicating if a good or bad news event occurred on day *t*. The table also shows differences between the coefficients on the good and bad news binary variables with the associated *t*-statistics. Good (bad) news days are those in the top (bottom) quintile of daily market-adjusted returns for firms with news events. We run regressions daily and report coefficient averages. ** and * indicate significance at the 1% and 5% level, respectively.

Panel A: Relative Call Open Buy Volume

	t-3	t-2	t-1	t	t+1	t+2	t+3
Ret_{-1}	18.71 **	24.48 **	25.07 **	12.66 **	18.63 **	29.95 **	21.64 **
Ret_{-2}	-24.43 **	2.25	2.57	5.08	-2.85	2.09	3.10
Good News Event	-0.69	-0.48	4.00 **	8.03 **	1.54 *	-0.13	-0.78
Bad News Event	-1.15 **	1.60 **	3.21 **	4.18 **	0.68	-0.36	-0.76
Good - Bad	0.46	-2.08 **	0.79	3.85 **	0.86	0.23	-0.01
t-statistic	(0.78)	(2.86)	(0.80)	(4.02)	(0.95)	(0.30)	(0.02)
N	649,686	648,979	649,783	689,271	648,286	646,011	644,822

Panel B: Relative Put Open Buy Volume

	t-3	t-2	t-1	t	t+1	t+2	t+3
Ret_{-1}	22.66 **	16.65	6.87	10.32	5.01	5.90	16.13 *
Ret_{-2}	-5.19	15.13 *	17.07	10.15	17.99 **	13.12	3.11
Good News Event	-0.68	1.20	4.10 **	6.25 **	1.78 *	-0.69	0.57
Bad News Event	-0.01	2.07 **	4.18 **	9.10 **	2.02 *	0.45	-0.39
Good - Bad	-0.67	-0.87	-0.08	-2.85 *	-0.24	-1.13	0.96
t-statistic	(0.84)	(0.71)	(0.08)	(2.20)	(0.20)	(0.92)	(1.03)
N	588,485	587,793	588,222	619,333	586,876	584,923	583,787

Panel C: Put-Call Open Buy Ratio

	t-3	t-2	t-1	t	t+1	t+2	t+3
Ret_{-1}	-0.31 **	-0.30 **	-0.30 **	-0.30 **	-0.28 **	-0.28 **	-0.29 **
Ret_{-2}	-0.06 *	-0.06 *	-0.06 *	-0.06 **	-0.06 **	-0.04	-0.05
Good News Event	0.05	0.34	-0.29	-3.20 **	-0.50 *	-0.13	0.34
Bad News Event	0.92 **	1.43 **	1.79 **	2.95 **	0.52 *	0.25	0.03
Good - Bad	-0.87	-1.09	-2.08	-6.15	-1.02	-0.39	0.31
t-statistic	(2.79)	(3.57)	(7.04)	(21.16)	(3.26)	(1.26)	(1.00)

Table 3. The Information Content of Option Volume

This table presents four-factor adjusted returns, in percent, following measurement of open buy ratios. Returns are presented using equal-weighting for days 1, 2, 3, 4 and 5 following measurement days. Open buy ratios are calculated as put open buy volume as a percentage of total open buy volume. Returns are presented after dividing firms into quintiles daily based on open buy ratios. Results are presented for all firm days (Panel A), including only measurement dates on days preceding news days (Panel B) and including only measurement dates on news days (Panel C). High-low quintile returns are also presented, along with *t*-statistics from difference of means tests. In Panel D differences of high-low low portfolio differences for all days relative to days preceding news days and news day are presented, with *t*-statistics for differences. For individual portfolios, significance levels are indicated for *t*-tests of mean differences from 0. *t*-statistics are corrected for firm and date clustering. ** and * indicate significance at the 1% and 5% level, respectively.

Panel A: All Days

Open Buy Quintile	Ret_1	Ret_2	Ret_3	Ret_4	Ret_5
Low	0.063 **	0.020	0.003	0.003	0.001
2	0.008	0.003	0.007	-0.021 *	-0.007
3	-0.001	-0.007	0.008	-0.004	0.007
4	-0.053 **	-0.017	-0.018	0.006	-0.015
High	-0.071 **	-0.042 **	-0.021 *	-0.020 *	-0.026 **
High-Low	-0.134 **	-0.061 **	-0.024	-0.023	-0.028 *
t-stat	(9.82)	(4.45)	(1.81)	(1.70)	(2.10)

Panel B: Preceding News Days

Open Buy Quintile	Ret_1	Ret_2	Ret_3	Ret_4	Ret_5
Low	0.239 **	0.088	-0.079	0.018	-0.074
2	0.064	-0.044	0.026	-0.048	-0.027
3	0.014	-0.018	0.019	0.080 *	0.068
4	-0.229 **	-0.047	-0.022	0.067	0.027
High	-0.344 **	-0.082	0.005	0.026	-0.063
High-Low	-0.583 **	-0.170 *	0.084	0.008	0.011
t-stat	(4.42)	(2.27)	(1.23)	(0.12)	(0.18)

Panel C: News Days

Open Buy Quintile	Ret_1	Ret_2	Ret_3	Ret_4	Ret_5
Low	0.140 **	0.033	-0.020	-0.016	0.003
2	-0.042	-0.029	0.023	-0.080 *	-0.010
3	-0.007	-0.008	0.068	0.053	0.046
4	-0.085 *	-0.006	0.047	0.045	0.044
High	-0.185 **	-0.019	-0.002	0.052	0.025
High-Low	-0.325 **	-0.052	0.019	0.068	0.021
t-stat	(4.96)	(0.83)	(0.31)	(1.21)	(0.38)

Panel D: High-Low Return Differences

	Ret_1	Ret_2	Ret_3	Ret_4	Ret_5
All - Preceding	0.449 **	0.108	-0.108	-0.030	-0.039
t-stat	(3.39)	(1.42)	(1.56)	(0.46)	(0.61)
All - News	0.191 **	-0.010	-0.042	-0.091	-0.049
t-stat	(2.86)	(0.15)	(0.69)	(1.57)	(0.85)

Table 4. Evidence on Where Informed Investors Trade

This table presents one-day four-factor adjusted returns following measurement of put-call open buy and open sell ratios. Open buy (sell) ratios are calculated as put open buy (sell) volume as a percentage of total open buy (sell) volume. Returns are presented after dividing firms into quintiles daily based on open buy (sell) ratios. Results are presented including only measurement dates on days preceding news days (Panel A) and including only measurement dates on news days (Panel B). To be included in the sample open buy and open sell ratios must be available for both the pre-news day and news day. Analysis is performed after separating firm days according to whether or notnews is scheduled. Earnings announcements are considered scheduled news and all other news is considered unscheduled. High-low quintile returns are also presented with *t*-statistics from difference of means tests. For individual portfolios, significance levels are indicated for *t*-tests of mean differences from 0. *t*-statistics are corrected for firm and date clustering. ** and * indicate significance at the 1% and 5% level, respectively.

Panel A: Days Before News

Open Buy Quintile	Unscheduled	Scheduled
Low	0.269 **	-0.091
2	0.129	0.009
3	-0.039	-0.102
4	-0.156	-0.622 **
High	-0.217 **	-0.191
High-Low	-0.486 **	-0.099
t-stat	(3.84)	(0.26)

Open Sell Quintile	Unscheduled	Scheduled
Low	0.012	-0.976 **
2	0.029	-0.225
3	-0.036	0.286
4	-0.079	-0.152
High	0.045	-0.116
High-Low	0.032	0.860 *
t-stat	(0.25)	(2.27)

Panel B: News Days

Open Buy Quintile	Unscheduled	Scheduled
Low	0.159 **	0.038
2	-0.042	0.035
3	-0.089	-0.092
4	-0.042	-0.113
High	-0.105 *	-0.310 **
High-Low	-0.264 **	-0.347 *
t-stat	(3.51)	(2.48)

Open Sell Quintile	Unscheduled	Scheduled
Low	0.008	-0.091
2	-0.057	-0.013
3	-0.006	-0.023
4	-0.018	-0.064
High	-0.063	-0.263 **
High-Low	-0.071	-0.171
t-stat	(0.92)	(1.16)

Table 5. Regression Analysis of Information Content of Option Volume

This table presents regression analysis where the dependent variable is one-day four-factor adjusted returns. Independent variables are the open buy or open sell ratio, underlying asset turnover, underlying asset bid-ask spread (all measured on the day prior to measurement of the dependent variable) and underlying asset returns over the five days prior to measurement of the dependent variable. Open buy (sell) ratios are calculated as put open buy (sell) volume as a percentage of total open buy (sell) volume. To be included in the sample data for all variables must be available for both the pre-news day regression and news day regression. Analysis is performed for the sample of all firms days (Panel A), separately where dependent variables are measured on days preceding news days and on news days (Panel B), and further separating the sample based on whether news is unscheduled (Panel C) or scheduled (Panel D). Earnings announcements are considered scheduled news and all other news is considered unscheduled. News days are those in the top and bottom quintile of daily market-adjusted returns for firms with news events (good or bad news). Standard errors used for determining significance levels are corrected for time and firm clustering. ** and * indicate significance at the 1% and 5% level, respectively.

Panel A: Full Sample

Intercept	0.055 **	-0.019
Open Buy Ratio	-0.149 **	
Open Sell Ratio		0.003
Turnover	0.000	0.000
Spread	0.006	0.006
$Ret_{[-5,-1]}$	-0.771 **	-0.759 *
N	471,085	471,085
R-Squared	0.07%	0.04%

Panel B: Pre-News and News Days

	Pre-News Days		News Days	
Intercept	0.299 **	-0.059	0.163 **	0.096
Open Buy Ratio	-0.659 **		-0.254 **	
Open Sell Ratio		0.137		-0.097
Turnover	0.002	-0.002	-0.004	-0.004
Spread	-0.281	-0.327	0.005	0.004
$Ret_{[-5,-1]}$	-1.374	-0.013	-1.310 **	-1.294 **
N	29,562	29,562	29,562	29,562
R-Squared	0.12%	0.04%	0.27%	0.24%

Panel C: Unscheduled News

	Pre-News Days		News Days	
Intercept	0.333 **	0.066	0.174 **	0.106
Open Buy Ratio	-0.676 **		-0.205 *	
Open Sell Ratio		-0.071		-0.046
Turnover	-0.002	-0.002	-0.005 *	-0.005 *
Spread	-0.278	-0.321	0.003	0.002
$Ret_{[-5,-1]}$	-1.911 *	-1.844 *	-1.348 **	-1.336 **
N	23,945	23,945	23,945	23,945
R-Squared	0.20%	0.09%	0.35%	0.32%

Panel D: Scheduled News

	Pre-News Days		News Days	
Intercept	0.188	-0.558 *	0.025	-0.037
Open Buy Ratio	-0.558		-0.446 **	
Open Sell Ratio		0.996 *		-0.288
Turnover	-0.007	-0.006	0.002	0.002
Spread	-0.374	-0.444	0.615	0.580
$Ret_{[-5,-1]}$	2.221	2.248	-1.149	-1.087
N	5,617	5,617	5,617	5,617
R-Squared	0.09%	0.15%	0.23%	0.15%

Table 6. Interactions with Measures of Private Information

This table presents four factor adjusted returns on 2 × 3 portfolios formed on put-call open buy trading volume and insider trades (Panel A) or implied volatility spreads (Panel B). OB denotes open buy ratios and OS denotes open sell ratios. Open buy (sell) ratios are calculated as put open buy (sell) volume as a percentage of total open buy (sell) volume. Results are presented including only measurement dates on days preceding news days. Analysis is performed after separating firm days according to whether or not news is scheduled. Earnings announcements are considered scheduled news and all other news is considered unscheduled. High-low returns are also presented with *t*-statistics from difference of means tests, where the *t*-statistics are corrected for firm and date clustering. In each case, the return in the lower right corner corresponds to a strategy that buys stocks with both positive option signals and positive insider trading signals and sells stocks with both negative option signals and negative insider trading signals.

Panel A: Insider Trading

	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low NTP	-0.260	-0.141	-0.250	0.010	(0.04)
High NTP	0.419	0.101	0.214	-0.205	(0.87)
High-Low	0.678	0.242	0.464	0.668	
t-stat	(2.57)	(0.99)	(1.78)	(2.57)	

	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low NTP	-0.678	-0.052	0.022	0.700	(2.47)
High NTP	0.181	0.193	0.337	0.156	(0.65)
High-Low	0.859	0.245	0.315	1.015	
t-stat	(3.22)	(1.00)	(1.22)	(3.93)	

Unexpected	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low NTP	-0.026	0.039	-0.222	-0.196	(0.67)
High NTP	0.419	0.135	0.082	-0.337	(1.45)
High-Low	0.445	0.095	0.303	0.641	
t-stat	(1.69)	(0.39)	(1.15)	(2.37)	

Unexpected	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low NTP	-0.294	-0.125	0.198	0.492	(1.72)
High NTP	0.425	0.031	0.202	-0.223	(0.96)
High-Low	0.719	0.156	0.005	0.497	
t-stat	(2.72)	(0.62)	(0.02)	(1.98)	

Expected	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low NTP	-1.047	-0.676	-0.324	0.724	(0.98)
High NTP	0.416	-0.024	0.666	0.250	(0.36)
High-Low	1.463	0.652	0.990	0.740	
t-stat	(1.94)	(0.98)	(1.45)	(1.10)	

Expected	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low NTP	-1.880	0.157	-0.497	1.383	(1.87)
High NTP	-0.828	0.811	0.776	1.604	(2.23)
High-Low	1.053	0.654	1.274	2.657	
t-stat	(1.38)	(1.02)	(1.83)	(3.66)	

Panel B: Implied Volatility Spread

	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low CPIV	0.180	-0.169	-0.430	-0.611	(4.12)
High CPIV	0.187	0.083	-0.065	-0.252	(1.99)
High-Low	0.007	0.253	0.365	0.618	
t-stat	(0.05)	(1.92)	(2.83)	4.79	

	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low CPIV	-0.253	-0.125	-0.167	0.086	(0.57)
High CPIV	-0.022	0.127	0.133	0.155	(1.25)
High-Low	0.231	0.252	0.301	0.386	
t-stat	(1.66)	(1.94)	(2.22)	2.73	

Unexpected	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low CPIV	0.220	-0.039	-0.387	-0.606	(4.00)
High CPIV	0.181	0.075	-0.028	-0.208	(1.67)
High-Low	-0.039	0.114	0.359	0.567	
t-stat	(0.27)	(0.86)	(2.77)	4.42	

Unexpected	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low CPIV	-0.064	-0.084	-0.148	-0.085	(0.55)
High CPIV	0.078	0.076	0.097	0.018	(0.15)
High-Low	0.142	0.160	0.245	0.160	
t-stat	(1.02)	(1.26)	(1.75)	1.12	

Expected	Low OB Tercile	OB Tercile 2	High OB Tercile	High-Low	t-stat
Low CPIV	0.000	-0.701	-0.592	-0.592	(1.37)
High CPIV	0.220	0.115	-0.213	-0.433	(1.07)
High-Low	0.220	0.816	0.378	0.811	
t-stat	(0.48)	(2.12)	(1.00)	2.03	

Expected	Low OS Tercile	OS Tercile 2	High OS Tercile	High-Low	t-stat
Low CPIV	-1.088	-0.294	-0.237	0.851	(1.98)
High CPIV	-0.484	0.334	0.269	0.753	(2.00)
High-Low	0.604	0.628	0.506	1.357	
t-stat	(1.39)	(1.54)	(1.37)	3.22	

Table 7. Contrarian Investing

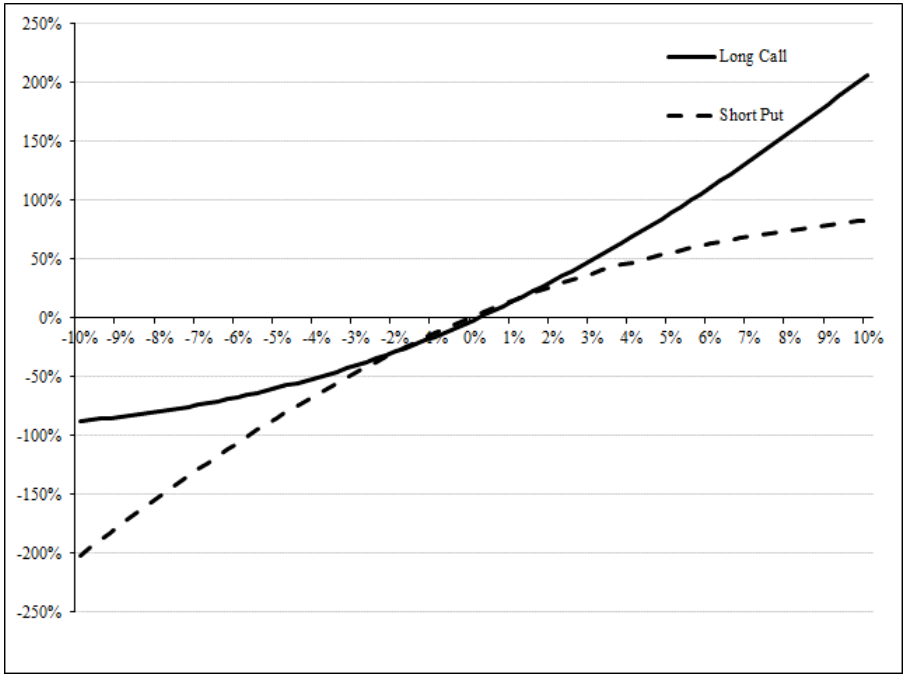
This table presents one day four-factor adjusted returns following measurement of open buy ratios on news days. Open buy ratios are calculated as put open buy volume as a percentage of total open buy volume. Firm days are divided into quintiles daily based on open buy. Results are presented after dividing firm days according to whether the open buy ratio on the new day contradicts the nature of the news event. If a news event is classified as Good (Bad) news based on market-adjusted returns and the open buy ratio is not in the bottom (top) half of daily open buy ratios, the signal is considered contrarian. If a news event is classified as Good (Bad) news based on market-adjusted returns and the open buy ratio is in the bottom (top) half of daily ratios, the signal is considered agreeing. News days are those in the top and bottom quintile of daily market-adjusted returns for firms with news events (good or bad news). Results are also presented after further dividing the sample based on whether or not news is scheduled. Earnings announcements are considered scheduled news and all other news is considered unscheduled. Differences between high and low quintiles returns for agreeing and contrarian samples are also presented for all news days, unexpected news and expected news. *t*-statistics for these differences are also presented. For individual portfolios, significance levels are indicated for t-tests of mean differences from 0. *t*-statistics are corrected for firm and date clustering. ** and * indicate significance at the 1% and 5% level respectively.

Open Buy Quintile	Agreeing	Contrarian	Agreeing Unscheduled	Contrarian Unscheduled	Agreeing Scheduled	Contrarian Scheduled
Low	0.092	0.107	0.078	0.136	0.156	-0.022
2	0.092	-0.080	0.083	-0.069	0.140	-0.113
3	0.042	-0.051	0.032	-0.081	0.090	0.094
4	-0.069	-0.128 *	-0.009	-0.097	-0.373 **	-0.278
High	-0.243 **	-0.056	-0.219	-0.012	-0.345 *	-0.238 *
High-Low	-0.334 **	-0.163	-0.297	-0.148	-0.501	-0.215
t-stat	(3.93)	(1.78)	(3.13) **	(1.46)	(2.66) **	(1.00)

Figure 1. Long Call and Short Put Returns when Jumps are Deterministically Timed

This figure shows long call and short put option returns in an extension of the Black-Scholes (1973) option pricing model augmented with randomly-sized but deterministically-timed jumps, as in Dubinsky and Johannes (2006). Panel A shows the one-day option return as a function of the daily underlying stock return when no news is scheduled to be released during the life of the option. Panel B shows the corresponding return when news is scheduled to be released the next day. Jumps that occur on predetermined dates can be interpreted as scheduled news releases. Jump size is log-normally distributed. The options are at the money, have one month to expiration, diffusive volatility of 30% and jump size volatility of 10%. Option positions are held for one day; for short positions we show the dollar profit and loss divided by the initial value of the option.

Panel A: No Scheduled News



Panel B: Scheduled News

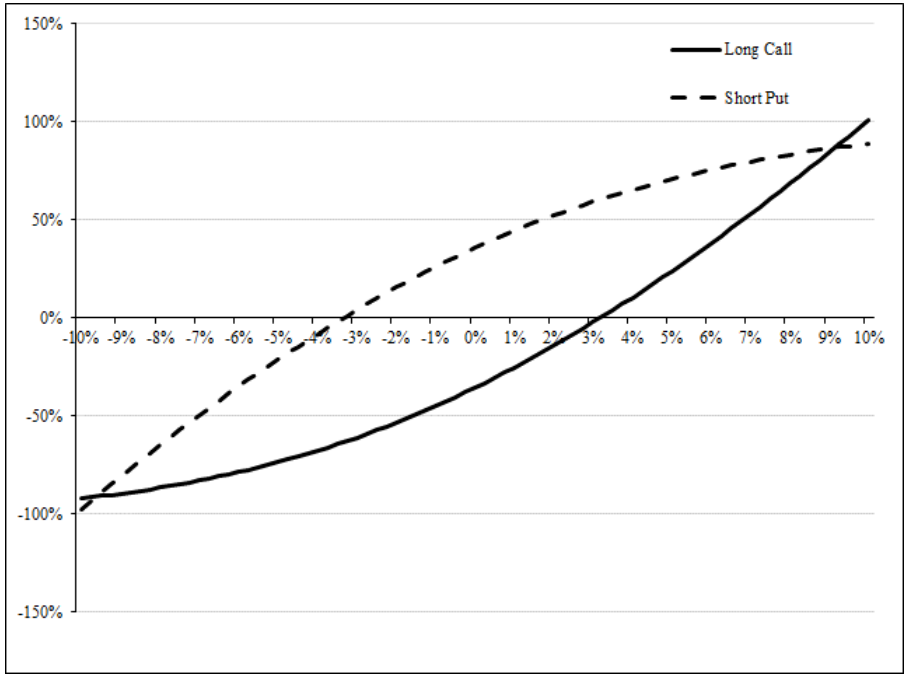


Figure 2. Daily Stock and Option Volume around News Events

This figure presents option volume, underlying asset and the ratio of option volume to underlying asset volume around news events. Each measure is calculated daily over the period [-5,5] relative to news events. Each day the measure is divided by the day -5 value. Medians of these values are presented in event time.

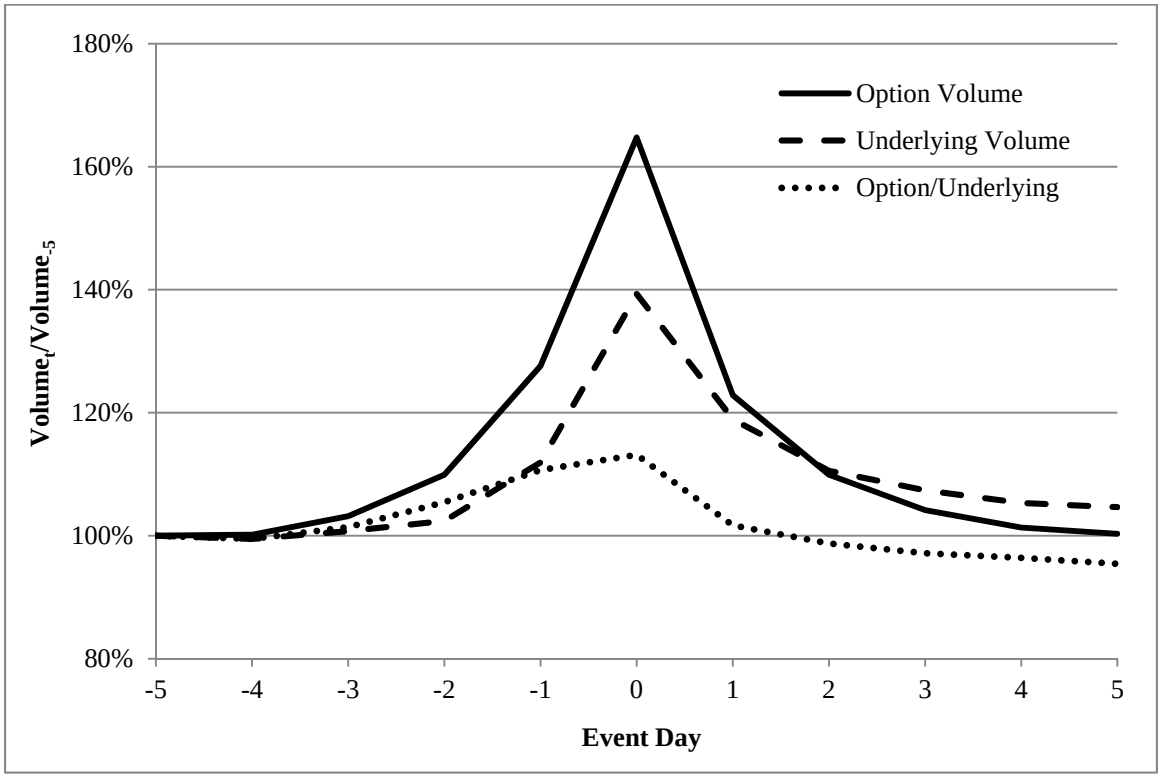


Figure 3. Open Buy Volume by News Type

This figure presents median values of call open buy volume, put open buy volume, and put open buy volume as a percentage of total open buy volume. Values are presented as a percentage of the same measure on day -5 over the period [-5,5] (where day 0 is a news day). News days in the top (bottom) quintile of market-adjusted returns are classified as good (bad) news days. Results are presented separately for good and bad news days. Call open buy, put open buy and put open buy percentage results are presented in Panels A, B and C, respectively.

Panel A: Call Open Buy Volume

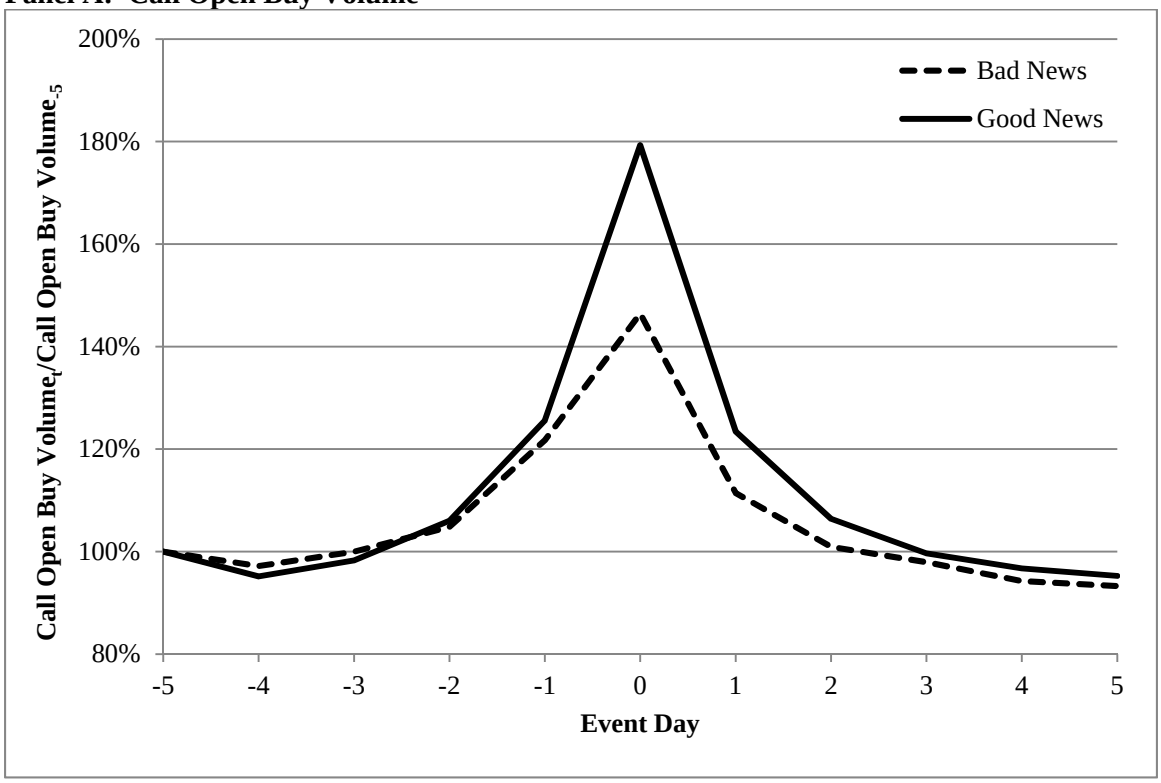
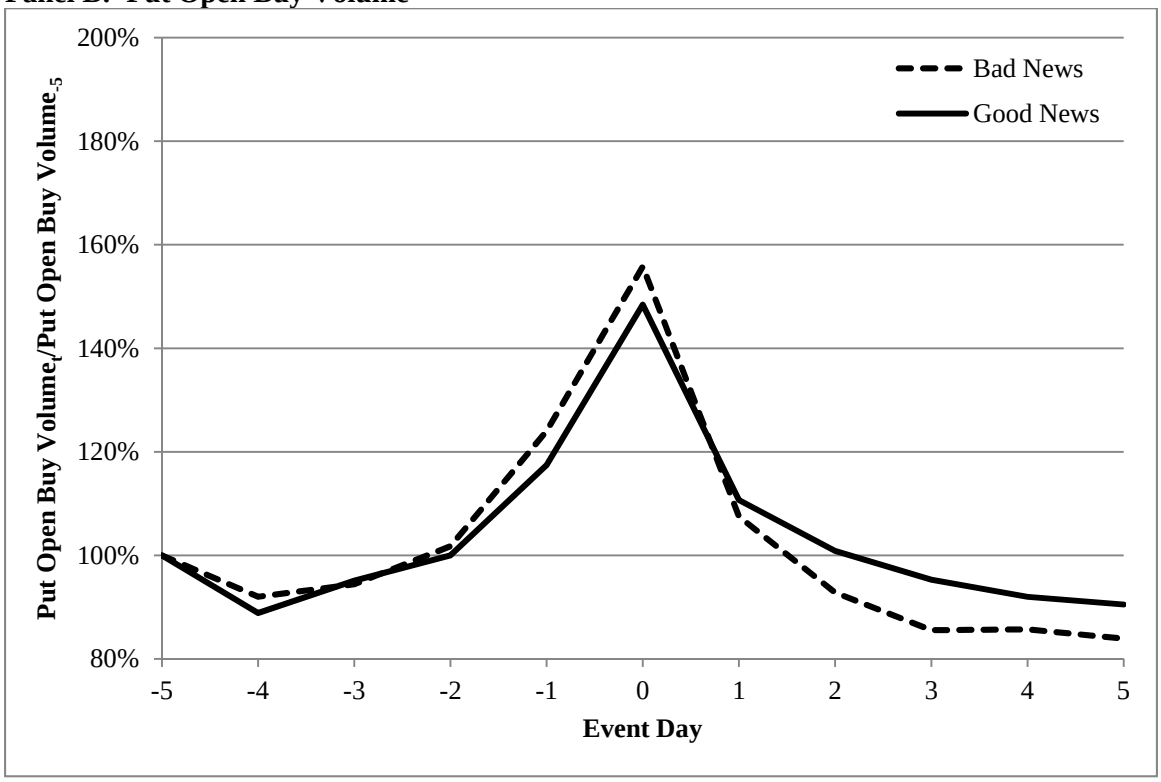


Figure 3 cont.

Panel B: Put Open Buy Volume



Panel C: Open Buy Put-Call Volume Ratio

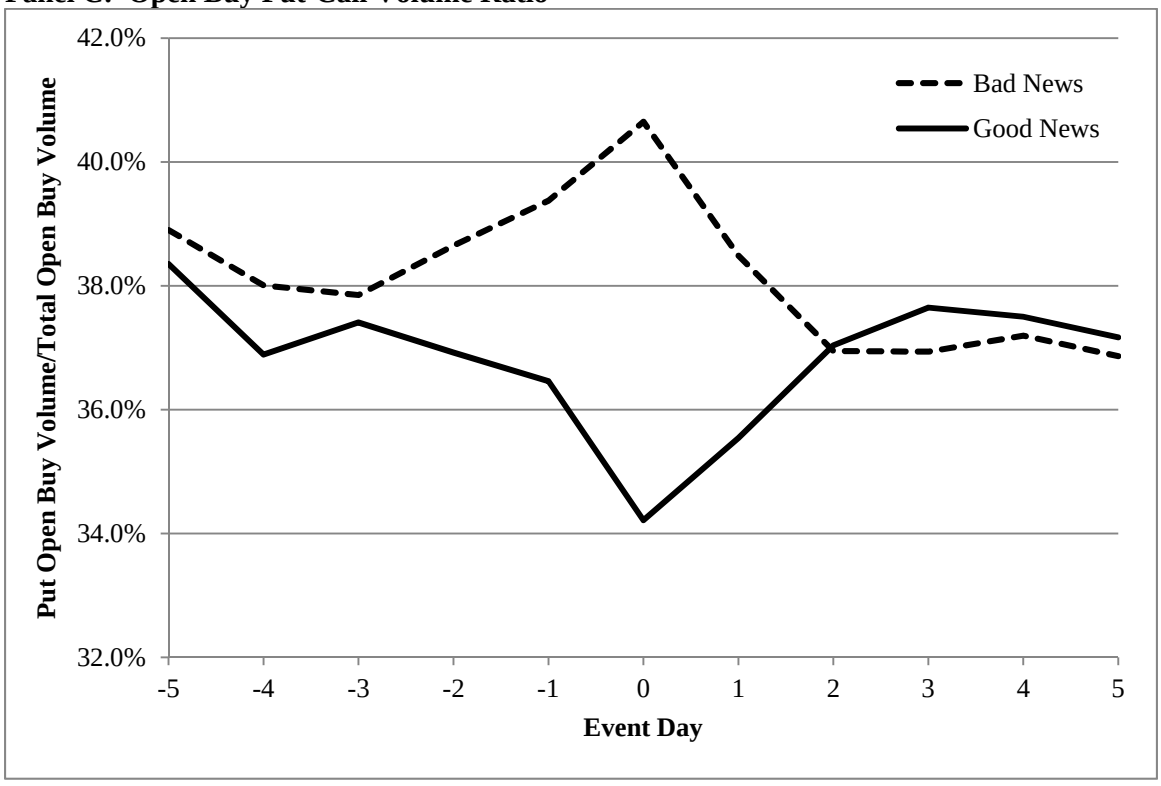


Figure 4. Uncertainty around News Events

This figure presents median values of implied volatility, underlying asset bid-ask spread and option bid-ask spread. Implied volatility is calculated as the open interest weighted implied volatility using all outstanding options. Underlying asset bid-ask spread is calculated on a percentage basis and option bid-ask spread is calculated on a percentage basis using open interest weighting. Values are presented as a percentage of the same measure on day -5 over the period [-5,5] (where day 0 is a news day). Days in the top and bottom quintiles of market-adjusted returns when news events occur are classified as news days. Results are presented separately for scheduled and unscheduled news. Earnings announcements are classified as scheduled news events and all other news events are classified as unscheduled. Call open buy, put open buy and put open buy percentage results are presented in Panels A, B and C, respectively.

Panel A: Implied Volatility

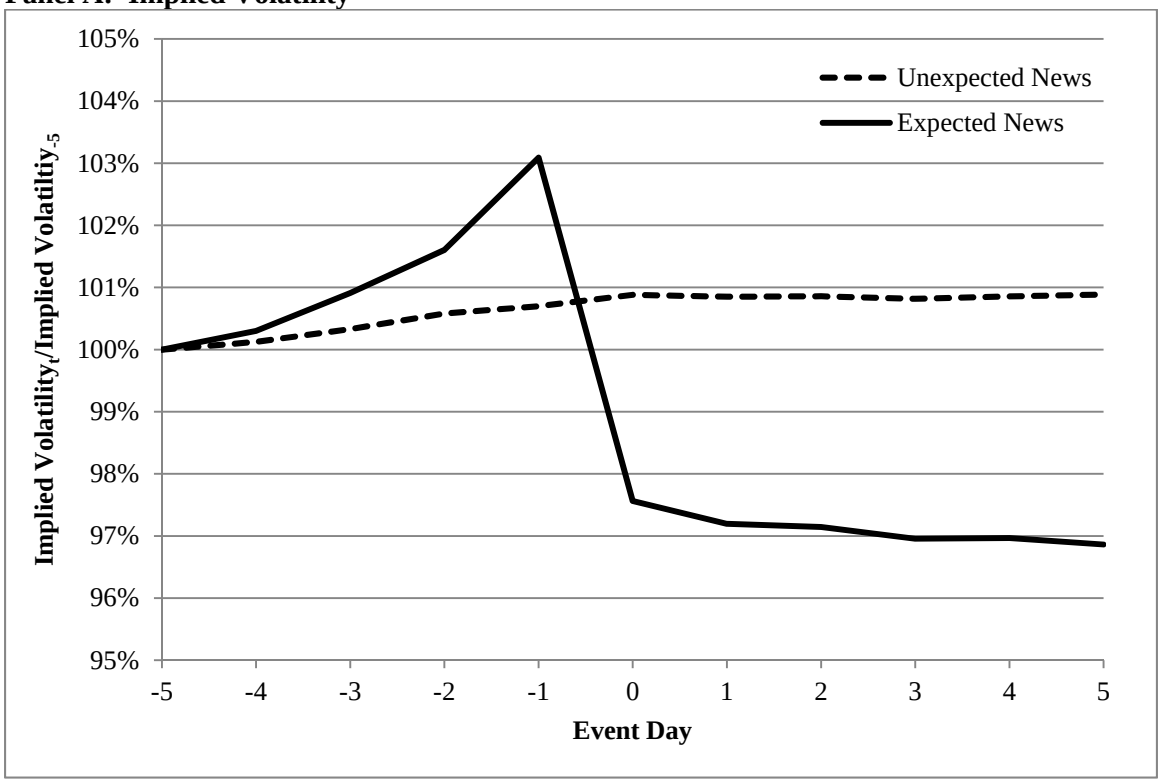
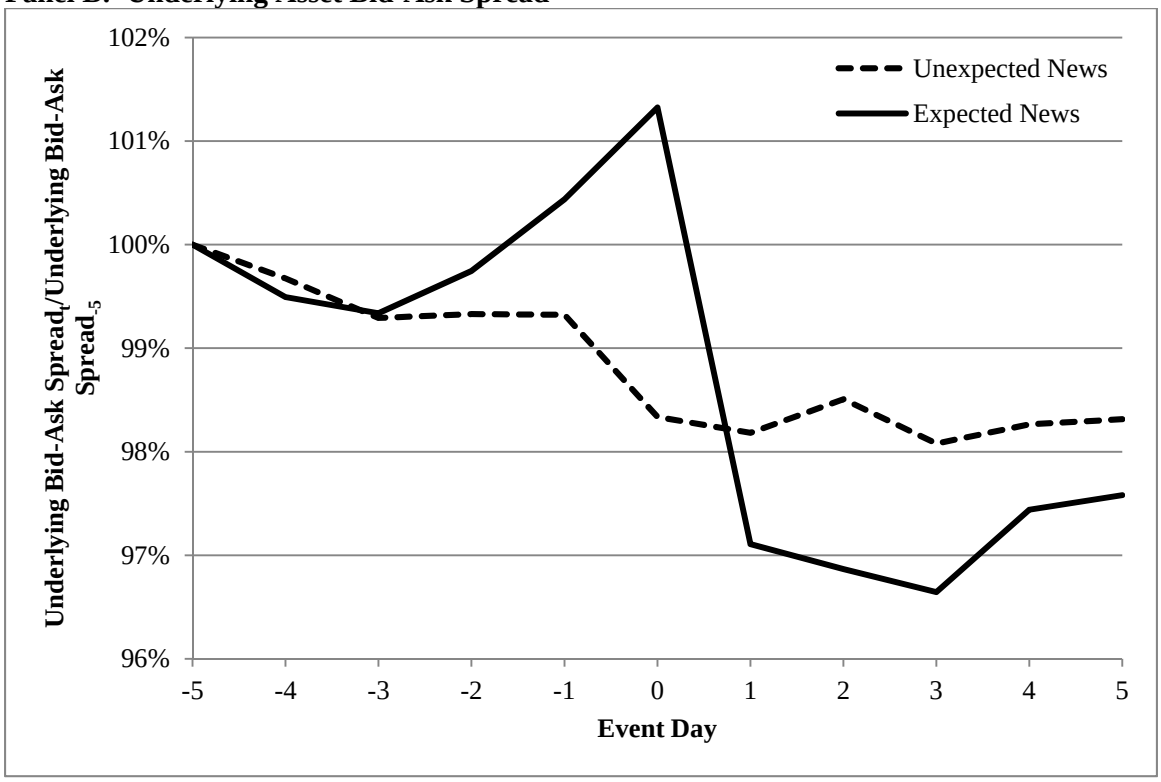


Figure 4 cont.

Panel B: Underlying Asset Bid-Ask Spread



Panel C: Option Bid-Ask Spread

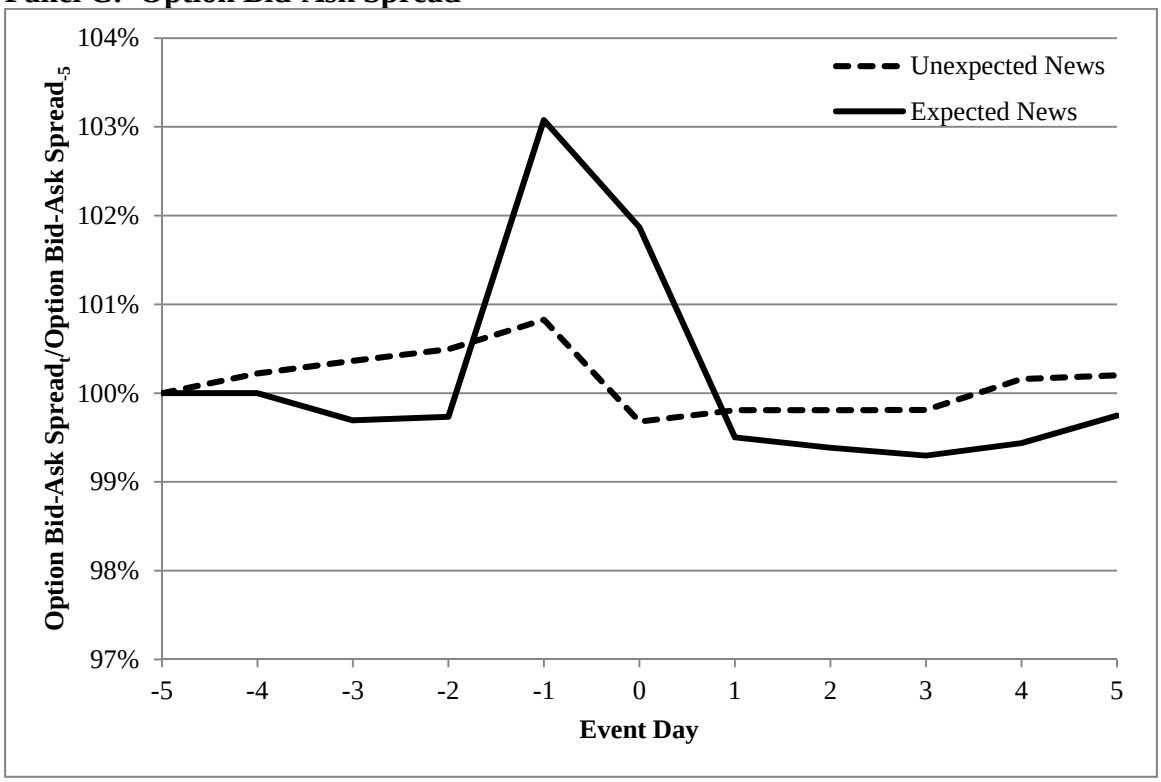
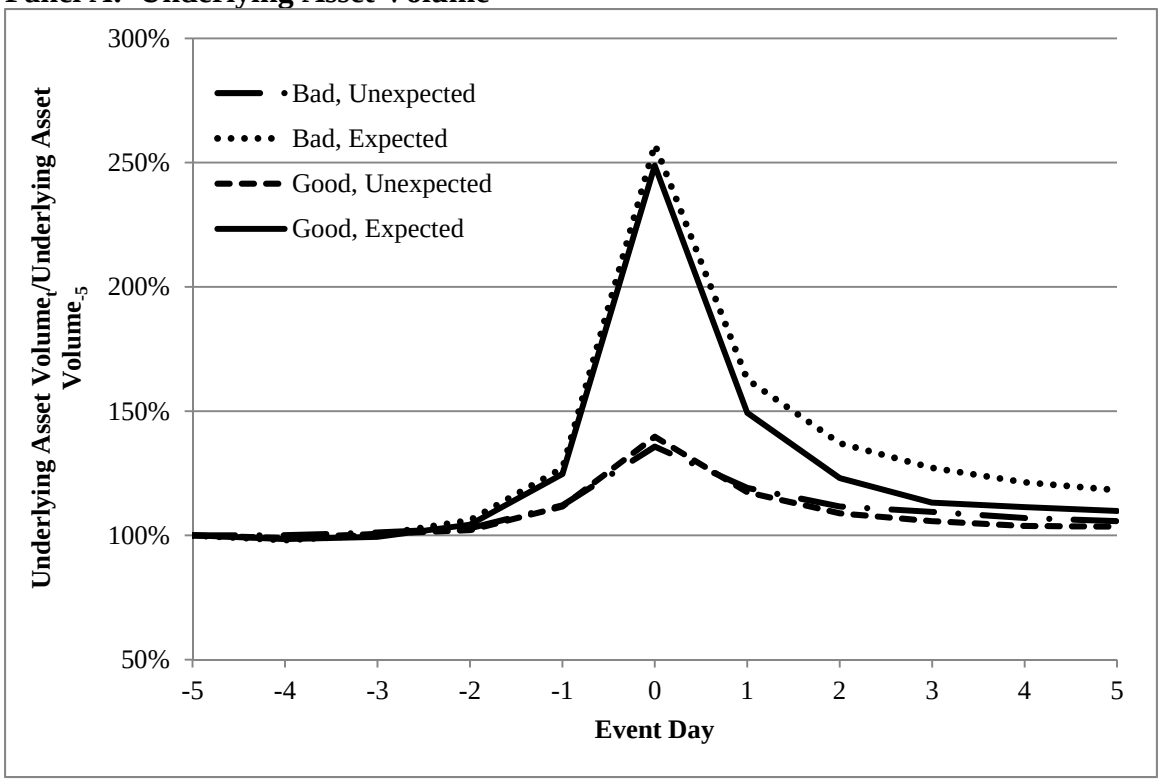


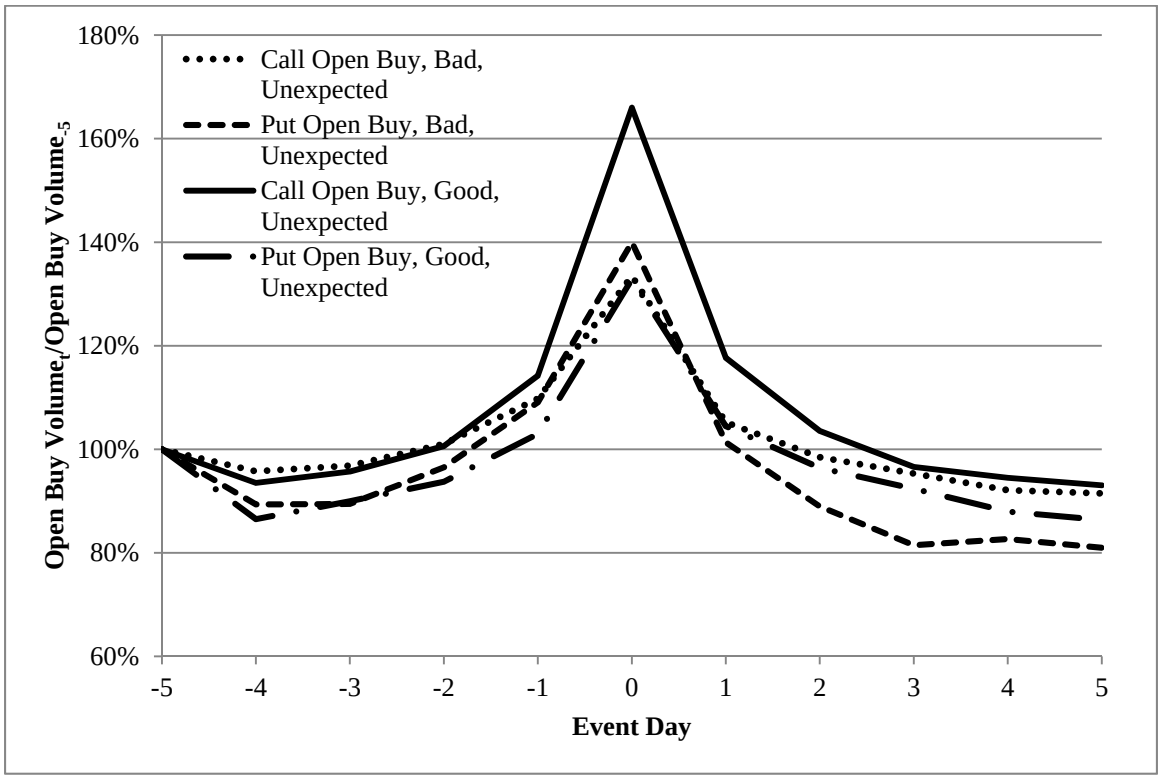
Figure 5. Volume around Expected and Unexpected News Events

This figure presents median values of underlying asset volume, call open buy volume and put open buy volume. Values are presented as a percentage of the same measure on day -5 over the period [-5,5], where day 0 is a news day. News days in the top (bottom) quintile of market-adjusted returns are classified as good (bad) news days. Results are presented separately after dividing news days based on if news was good or bad and scheduled or unscheduled. Earnings announcements are classified as scheduled news events and all other news events are classified as unscheduled. Underlying asset volume results are presented in Panel A. Call open buy and put open buy results are presented for unexpected news in Panel B and expected news in Panel C.

Panel A: Underlying Asset Volume



Panel B: Unscheduled News



Panel C: Scheduled News