The Informational Content of Option Volume Prior to Takeovers

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October 27, 2000

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Abstract

This paper examines informed trading in the options versus the stock market prior to takeover announcements. Prior to an announcement, the percentage increase in call volume for target firms is roughly four times as large as the increase in stock volume. Moreover, pre-announcement option volume is the heaviest in those takeover targets that experience the highest announcement-day returns. Short-term out-of-the-money calls experience the largest increase in buy-side trading, suggesting that the activity is dominated by those who are relatively certain an announcement will occur soon. We also use volume-triggered trading rules to further assess the relationship between call volume and future returns as well as the profitability of option trading prior to takeovers. Trading profits are increasing in the amount of call volume required to trigger a buy signal. However, similar trading rules using stock volume reveal no such patterns. When these trading rules are applied to all firms with options listed on the CBOE, large increases in call-option trading are again followed by higher subsequent returns. Our results indicate that between the options and the stock markets, informed investors prefer to trade on the former market. Thus, the options market is more conducive to information and price discovery.

1 Introduction

The capital-allocation role of financial markets rests crucially on the informational efficiency of security prices. For the capital allocation determined by markets to be efficient, it is essential that security prices reflect all relevant information fully and accurately. Then, what types of security market are the most conducive to price discovery and information incorporation? Clearly, some markets are particularly attractive to informed traders, while others may not be. Within the same type of security market, different contract designs may lead to different benefit levels for information-based trading and investing. To investigate these issues, this paper focuses on a particular type of event, merger/takeover announcements, and examines the relative conduciveness of the stock versus the options markets for information and price discovery. The idea that the options market may provide a lower-cost, more effective venue for informed trading can be traced back to Black (1975):

> *Since an investor can usually get more action for a given investment in options than he can by investing directly in the underlying stock, he may choose to deal in options when he feels he has an especially important piece of information... So many information traders will go to the options market rather than to the stock market. And many potential information traders will trade on the options market when they wouldn't bother to trade at all if the options market did not exist. This means that in some cases a market maker or specialist will face a more dangerous trading environment on an options exchange than the specialist on the same stock faces on a stock exchange.*

In addition to offering more leverage, options contracts are more attractive to informed investors than the underlying stock for two other reasons. First, the payoff to an option is truncated at the strike price point, limiting the downside to the investor. In this sense, the leverage offered by an option comes with a specifically limited risk, whereas the leverage provided by a conventional loan or a highly margined equity position contains far more extended risk (i.e., the exposure is 100% of the stock's downside). Second, options are not redundant securities. In option pricing theory it is

known that when the underlying stock price follows a one-dimensional diffusion process, an option in a perfect-market environment can always be replicated by combining the underlying with a risk-free asset. In real life, however, information is often asymmetric (especially before major corporate announcements) and trading frictions (e.g. transaction costs, short sale and capital constraints) are abundant, making options non-redundant. For instance, Back (1993) shows that with asymmetric information option and stock volumes convey different information and thus it is not possible to replicate an option with the underlying stock.

However, options are also generally associated with higher proportional transaction costs, less liquidity, and trading in options may be more transparent due to lower volume levels. Thus, it is an empirical question as to whether informed traders indeed prefer to trade in options. In the existing literature, several studies have examined the general question of whether options trading changes the informational efficiency of equity-related markets. For example, Klemkosky and Maness (1980), Jennings and Starks (1986), Conrad (1989), Skinner (1990), Damodaran and Lim (1991), Mayhew, Sarin, and Shastri (1995), and Kumar, Sarin, and Shastri (1998) find that stocks with options traded on them generally have greater price efficiency. Whereas Manaster and Rendleman (1982), Bhattacharya (1987), Vijh (1988, 1990), Anthony (1988), Stephan and Whaley (1990), Chan, Chung, and Johnson (1993), and Fleming, Ostdiek, and Whaley (1996) present mixed evidence as to whether the options market leads the underlying stock market in price discovery. Easley, O'Hara, and Srinivas (1998) provide new insight by modeling the profit maximizing decision rule of the informed trader. They show that informed traders may sometimes choose the options market over the stock market, making option volume often lead underlying stock returns.

These existing studies have, however, not *directly* answered the question of whether the options or stock market is more informative. Without focusing on specific information-revealing events, one cannot be sure whether the lead-lag activity link between the options and the stock markets is simply due to transmitting speculative noise from one market to another. By examining trading activity on different types of markets prior to event times, we can detect which market type indeed attracts more of the informed trading because, prior to such event times, informational asymmetries should

be large and the desire for the informed to trade should be high. In this respect, our analysis is similar in spirit to Amin and Lee (1997), who examine options trading surrounding earnings announcements. They find evidence of informed trading in the options market, and that there is increased buying activity before positive earnings announcements.[1] As pointed out by Skinner (1997), however, since approximate earnings announcement dates are known a priori, it is not clear what fraction of the increase in pre-announcement trading is due to the presence of informed traders. Given that earnings surprises are usually on the positive side,[2] experienced traders may take on option positions (betting on the upside) prior to approximate announcement dates, regardless of whether they have any inside information or not.

In contrast, merger/takeover announcements are sometimes unpredictable even by insiders. Consequently, it is much harder for anyone to time a speculative trade before a merger, unless one truly has material information regarding the deal. Given the announcement-time uncertainty and the risk of a merger negotiation falling apart, these events are especially suitable for addressing the relative conduciveness of the options versus the underlying stock market for informed trading. In addition, the incentives to engage in informed trading are much higher prior to these announcements (because there is usually a high takeover-bid premium) than earnings announcements.[3]

Overall, we find substantial evidence of informed trading in the options market prior to takeovers. Call volume increases dramatically prior to takeovers, and this increase is much greater than that occurring in the underlying stock. Five days prior to a takeover announcement, the increase in average volume is 321 percent for calls, 168 percent for puts, and only 76 percent for stocks. Among firms, pre-announcement call volume is particularly high for targets with high takeover premi-

[1] According to Amin and Lee (1997), option trading activity foreshadows subsequent earnings announcements in that 56.1 percent of option positions are on the long side prior to positive announcements, as compared to only 52 percent prior to negative earnings surprises.

[2] In recent years, firms tend to preannounce if they expect the current quarter's earnings to be even slightly short of Wall Street analysts' expectations. Consequently, by the actual earnings announcement time the analyst expectations normally have been reduced enough that the earnings surprises are more positive than negative.

[3] There is a large empirical literature examining informed trading in the stock market prior to takeovers. But, research on the nature of option trading activity prior to merger announcements is limited. Barone-Adesi, Brown, and Harlow (1992) examine whether implied volatilities of tender offer targets after the announcement date reflect the eventual probability of successful completion. Levy and Yoder (1993) find that implied volatility increases for 21 target firms (but not for bidder firms) three days prior to a takeover announcement.

ums. In contrast, the underlying stock volume has virtually no predictive power of subsequent bid premiums. Thus, options market activities foreshadow future stock price movements, whereas the underlying stock volume does not. This supports the notion that the options market is more conducive to price discovery than the stock market. Consistent with bets on a large upside move, increases in implied volatility are the highest for *out-of-the-money* calls in the 30 days prior to an announcement. Classifying trades as buyer- or seller-initiated, we find that volume increases for *out-of-the-money* calls are driven by larger increases in buyer-initiated trades. *At-the-money* calls also experience a larger increase in buyer-initiated than seller-initiated trades, while *in-the-money* calls experience a larger increase in seller-initiated trades prior to takeovers. For puts, a larger fraction of the volume increase can be attributed to seller-initiated trades, which also translates into bullish positions on the stock. Interestingly, options trading in the month prior to a takeover announcement is concentrated in contracts with less than two months to expiration. Contracts with longer times to expiration exhibit relatively small increases in volume. In sum, options with different moneyness and maturity provide much richer information about the nature and terms of a pending takeover than the underlying stock market; The favored option strike prices often indicate where the future takeover-bid prices will lie, and the chosen option maturities provide clues to when an announcement will occur.

After showing that the options market is more efficient for informed trading, it is natural to search for the best mechanisms to extract the information contained in the options versus the underlying stock market activities. Toward this goal, we study several trading rules in which a buy signal is triggered whenever call volume or the underlying stock volume exceeds a preset threshold level. First, when only takeover target firms are included in this exercise, it is found that the higher the call-volume trigger level for a buy, the larger the trading profits from purchasing either calls or the underlying stock. Even after taking into account the bid-ask spreads for options, we find that the trading profits are still positive, economically significant and monotonically increasing in the buy trigger level, when the buy triggers are based on call-option volume. On the other hand, if we use the underlying stock volume as the basis to trigger a buy, the trading profits are far lower

and less significant. Furthermore, there is no strong association between trading profits and the stock-volume trigger level. Thus, the underlying stock volume is not as informative about future price movements as the option volume.

Next, we apply these trading rules to all firms (not just the ones in our takeover target sample) with options contracts traded on the Chicago Board Options Exchange (CBOE) between 1986 and 1994. In this out-of-sample exercise, call-volume-based trading profits are still increasing with the threshold trigger level, and generally positive before but not after accounting for transaction costs. However, if the buy triggers are based on the underlying stock volume (instead of option volume), profits are not increasing in the volume threshold and the corresponding trading profits are not as large as those using option volume. Therefore, even out of sample, the options activities are more informative about the firm's future than the underlying stock volume. To sum up, our trading rule analyses using both samples confirm our earlier conclusion that the options market attracts more informed trading than the stock market.

Our study adds to the existing literature on insider trading prior to merger/takeover announcements. As mentioned earlier, existing studies have documented evidence of large pre-announcement stock price and volume increases (e.g., Keown and Pinkerton (1981), Jarrell and Poulsen (1989), Cornell and Sirri (1992), Meulbroek (1992), Barclay and Warner (1993), Schwert (1996), and Meulbroek and Hart (1997)). Our study shows that even though there are abnormal pre-announcement activities in the stock market, there is far more information embedded in the options market activities about pending events. It should be noted that in these existing studies the focus has often been on "illegal" insider trading. In our paper, however, the focus is on the price-discovery aspect of securities markets where informed traders are not necessarily insiders or investors who have obtained inside information illegally. One may extract "information" legally by employing, for example, merger prediction models (based on either business knowledge, economic fundamentals, or market trading activities), or by simply tracking the flights of M&A specialist firm planes.[4] On

[4]Especially in the 1980's, firms that KKR executives visited often were likely takeover targets. Thus some traders found it advantageous to trade based on this information. Today for a fee one can obtain the flight logs of corporate

the other hand, as documented by, for example, Cornell and Sirri (1992) and Meulbroek (1992), insiders do trade illegally prior to merger announcements. Even though it is useful to document the fraction of trades that are due to insiders, it is infeasible for us to identify those trades from our data.[5] Consequently, we say trading is "informed" if its direction foreshadows subsequent stock price movements.

The remainder of the paper is organized as follows. Section 2 describes the takeover target sample. The pre-announcement volume for calls, puts, and stocks as well as other summary statistics is discussed in Section 3. Section 4 examines the relative informativeness of call and stock volume in explaining subsequent announcement day returns. The types of option in terms of moneyness and maturity traders prefer prior to announcements is analyzed in Section 5. Section 6 characterizes option-volume increases for heavily versus thinly traded options, as well as for stocks with small versus large pre-announcement and announcement-day returns. Using the takeover sample, Section 7 examines the profits to trading according to buy signals generated respectively from call-option and stock volumes. Section 8 re-examines these issues using the entire sample of firms whose options were traded on the CBOE between 1986 and 1994. Section 9 addresses robustness issues. Section 10 offers concluding remarks.

2 Data Description

Our takeover sample consists of all firms that were merger or tender-offer targets and had options listed on the CBOE between 1986 and 1994. Takeover announcements are first identified by the Security Data Corporation (SDC) database. The announcement day is verified by finding the first newspaper or online news indicating the terms of the acquisition on the Lexis/Nexis and/or

jets over the internet (The Wall Street Journal, October 29, A1, 1998). Even though, the flight logs are not generally considered public information, trading on this information is not due to leakage from corporate 'insiders' nor is such trading illegal.

[5]Seyhun (1986, 1988) examines all registered insider trading reported to the SEC and finds that insiders generally earn abnormal returns. Bettis and Coles (1997) find that registered insider purchases actually decline prior to merger announcements. Yet, as Meulbroek (1992) argues, most pre-takeover trading by insiders is not reported and thus she examines unreported insider trades that were subsequently prosecuted by the SEC. Yet, this is only a partial solution as clearly not all insider trading is detected by the SEC.

Dow Jones news retrieval service. Announcements after 4:00 p.m. are classified as occurring the following trading day. In order to insure that the announcements are truly original, we only examine target firms that had received no other tender offers in the previous year. Intraday option prices and volume are obtained from the Berkeley Options Database (BODB), while daily stock prices, volume, dividend distribution and stock split information are from the Center for Research in Security Prices (CRSP). Firms are required to have at least 200 days of valid pre-announcement option data and stock information. Relatively few firms have options listed on the CBOE especially during early years of the sample. Firms with listed options are typically larger than the average takeover firm. Thus, our final sample of 78 successful and unsuccessful takeover targets between 1986 and 1994 is tilted towards large target firm.[6] For each target firm in our sample, intraday option data are extracted from the BODB, for the period starting one year prior to, and ending one year after, the takeover announcement day (or, if the firm's options were delisted from the CBOE prior to the first announcement anniversary, the delisting date would be the ending date).

We examine option trading activity by using intraday option trades and quotes. In addition, we investigate changes in implied volatility surrounding the takeover announcement. To estimate the implied volatility with option data, it is necessary to specify an option pricing model, and to have information of the interest rate and dividend distributions. In this paper, we use the Black–Scholes model and ignore the issue of early exercise premium for American–style options. The Black–Scholes model is not perfectly specified. Nonetheless, it is widely used by practitioners and yields reasonable estimates of the implied volatility, especially for options with small amounts of dividend distribution. Daily Treasury-Bill bid and ask discounts with maturity up to one year are hand-collected from the *Wall Street Journal*. The average of the bid-ask discounts is used and converted to an annual rate. For each option contract in the sample, the two Treasury Bills which straddle the option's expiration date are used to compute the yield to maturity. Further, the stock prices are adjusted for dividends by subtracting the present value of future dividends to obtain the

[6]The number of firms with options listed on the CBOE has increased over time. For example, about 180, 230 and 650 firms list options on the CBOE in 1986, 1990 and 1994, respectively.

stock's dividend-exclusive price.

By convention, a call-option is said to be *at-the-money* (ATM) if its stock price divided by its strike price $(\frac{S}{K}) \in (0.95, 1.05)$; *out-of-the-money* (OTM) if $\frac{S}{K} \leq 0.95$; and *in-the-money* (ITM) if $\frac{S}{K} \geq 1.05$. Similar terminology is defined for puts by replacing $\frac{S}{K}$ with $\frac{K}{S}$. An option is said to be *short–term* if it has less than two months to expiration and *long–term* if it has greater than two months to expiration. Finally, we define the announcement date as *date 0*; the period from date -200 to date -100 ([-200,-100]) as the *benchmark period*; and the one month from date -30 to date -1 ([-30,-1]) as the *pre-announcement period*.

3 Pre-Announcement Activities

Our first task is to document the nature of trading activity across markets prior to takeover announcements. Table 1 presents summary statistics of volume, bid-ask spread and implied volatility (where applicable) for calls, puts, and stocks, and for both the benchmark [-200,-100] and the pre-announcement period [-30,-1]. For each variable of interest and for each target firm, we first calculate the average of the variable respectively over the benchmark and pre-announcement periods. Then, we obtain the cross-sectional mean for the variable. To gauge the significance of change in each variable between the two periods, we use a standard t-test and a non-parametric Wilcoxon rank-sum test which is more robust when the distribution of the test statistic is non-normal.

On average, there are 402 call contracts traded per firm per day in the benchmark period and 936 contracts per day in the pre-announcement period. This represents an average increase in call volume of 132.8% between the two periods. Puts experience a 76.6% increase while stocks a 36.8% increase in volume. Examining the changes in the number of trades between the periods (not displayed in Table 1) reveals similar results, because the average trade size is relatively similar between the periods. The average put/call ratio decreases by a statistically significant 22.8% from the benchmark to the pre-announcement period,[7] which is consistent with the larger volume increase

[7]The put/call ratio reported here is calculated using their respective trading volume. Ideally, the open-interest

in calls than in puts.

The average volume for the entire one-month pre-announcement period actually understates the trading dynamics for the days closer to the announcements. To see this, we plot in Figure 1 the respective time-series of average daily call, put, and stock volumes from date -100 to date +50, where date 0 is the event date. For each type of security and on a given date (relative to the event date), the cross-sectional average of daily volume is scaled by the average daily volume of that security from date -200 to date -100.

Several patterns emerge from Figure 1. First, stock, call and put volumes each begin to increase around date -30, where the relative volume increase is much greater in options (particularly in calls) than in the underlying stock. For example, on date -20 trading volume is 86% higher for calls, 66% higher for puts, and 36% higher for stocks, than their respective benchmark-period levels. On date -5, the increase in volume is 321% for calls, 168% for puts, and 76% for stocks. Second, on the announcement day, average volume both for options and for the underlying stock are dramatically higher than their respective benchmark levels. Volume increases by 1225% for calls, 895% for puts, and 987% for stocks. The pattern revealed most clearly by Figure 1 is that call-option activity supercedes stock market activity. Instead of average trading volume, we use each security type's median volume to measure activity changes during the pre-announcement days, and find a similar conclusion. For example, the median volume three days prior to the announcement date is 327% higher for calls, 275% higher for puts, and 76% higher for stocks. Figure 1 suggests that the options market activity foreshadows future value-enhancing events, and that the options market attracts relatively more informed trading than the stock market.

After the announcement, stock volume decreases dramatically but option volume remains high relative to previous levels. In particular, changes in average put volume are consistently greater than in average call volume in the post-announcement period. For example, on date +5 the average call volume is 530% of its benchmark level, whereas the average put volume and stock volume are

ratio between puts and calls should be more telling. However, the open-interest numbers are not available from the Berkeley Options Database.

627% and 209% of their respective benchmark-period levels. This increase in post-announcement put volume can be a result of hedging and "risk-arbitrage" to lock-in takeover premiums, because the takeover may actually fail.

Intuitively, if informed traders are present in the pre-announcement period, the bid-ask spread should increase due to the presence of a more severe adverse-selection environment. In Table 1, call (put) options experience a 5.5% (5.2%) increase in the dollar bid-ask spread. But, because call prices tend to go up prior to the announcement, their percentage bid-ask spreads show a 2.6% decline from the benchmark to the pre-announcement period (for puts, the decline in bid-ask spread is 3.0%). For a typical option, its bid-ask spread is around 15% of the option's price. One possible explanation for the decrease in the percentage bid-ask spread is that while the adverse selection component of an option's bid-ask spread increases, changes in the cost of market making may still be below the minimum tick size, such that the dollar bid-ask spread does not change significantly. Given that call-option prices typically increase prior to an announcement, a small increase in the dollar bid-ask spread for many options may actually make the percentage bid-ask spread slightly lower. Therefore, even though the adverse selection cost may be relatively severe ahead of takeover announcements, option contracts' bid-ask spreads may not be informative of the pending events.

To gauge whether investors pay a high price for options prior to takeovers, we examine changes in Black-Scholes option-implied volatility.[8] Specifically, we first calculate the average implied volatility across all contracts for each day and for each firm. Next, we obtain the cross-sectional average of the implied volatility for each day during the benchmark and pre-announcement periods. The results reported in Table 1 show that investors indeed pay a higher premium for options prior to takeovers. For calls, the implied volatility increases from 45.3% to 50.1%, a 10.6% increase. A similar increase in implied volatility is documented for puts in Table 1. Finally, the cumulative abnormal stock returns (in excess of the NYSE value-weighted portfolio returns) are 9.6% and 12.9%, respectively, for the benchmark and pre-announcement periods. The pre-announcement return is similar to the

[8]There is a one-to-one mapping between option price and implied volatility, regardless of which option pricing model is used.

13.3% cumulative pre-announcement price run-up found by Schwert (1996) in a comprehensive sample of 1,814 target firms.

4 Relative Informativeness of Options versus Stock Markets

The preceding section has demonstrated abnormal trading activities in both the options and stock markets. Before analyzing such activities in further detail, let us answer the following questions: Do these activities foreshadow future events? If such increased trading is not pure noise, which type of market is more predictive of future events? We estimate a cross-sectional regression of the two-day cumulative abnormal returns from date -1 to date +1, denoted by $CAR[-1, 1]$, where the explanatory variables are pre-announcement stock-volume change ($\Delta Volume^{stock}$), pre-announcement option-volume change ($\Delta Volume^{call}$), and pre-announcement stock-price run-up ($CAR[-30, -1]$):

$$CAR[-1, 1]_i = \beta_0 + \beta_1 CAR[-30, -1]_i + \beta_2 \Delta Volume_i^{call} + \beta_3 \Delta Volume_i^{stock} + \epsilon_i, \quad (1)$$

where all volume changes are the respective differences in logarithmic volume from the benchmark to the pre-announcement periods.

The regression results are displayed in Table 2. We consider three alternative specifications. The first model includes stock price run-up, change in option volume, and change in stock volume. The second and third specifications include dummy variables regarding the type of merger activity. In the first regression the coefficient on pre-announcement stock-price run-up ($CAR[-30, -1]$) is negative but insignificant. This is consistent with Schwert's (1996) finding that pre-announcement price run-up bears only a weak negative relationship with post-announcement price markup.[9] The coefficient on call-volume change is positive and statistically significant (the t-statistic is 2.14). In addition, pre-announcement stock-volume changes are negatively associated with announcement

[9]Schwert examines the entire "markup" premium paid to targets, including returns from the post-announcement day to the completion or incompletion of an offer.

returns (the t-statistic is -1.94).[10] We also control for other factors that have been shown to influence pre-announcement takeover activity, including dummy variables each for a publicly traceable rumor occurring within the six months prior to announcement, for a completed takeover, for the attitude of takeover (friendly or hostile?), and for the primary method of payment (cash?). As shown in Table 2, controlling for these factors does not significantly alter the coefficient and significance of option-volume changes.

These results suggest that informed trading is present in the pre-announcement options market. Otherwise, if the activity documented in the preceding section were due to speculative noises alone, there would not be a significant association between post-announcement returns and pre-announcement option trading activity. But, is there usually informed trading in the underlying stock market prior to announcements? The regression results indicate that the "surprise" component in a merger announcement is not related to pre-announcement stock activities. However, the evidence in Table 1 and Figure 1 suggests that abnormal trading does occur in the underlying stock during the pre-announcement period [e.g., Meulbroek (1992)]. A possible explanation for this result is that some information (through informed trading in the stock market) may already be reflected in the stock price prior to announcement. At the time of announcement the takeover premium is a true "surprise" to the stock market participants. On the other hand, only part of the information behind informed option trading may be reflected in the underlying stock price before a takeover announcement. Consequently, pre-announcement call-option volume changes can still foreshadow pending events and be a significant predictor of future takeover-premium "surprises." Table 2 thus supports the notion that the options market attracts a relatively larger proportion of informed investors and thus may contain more information about future events.

[10]The results from the regression with only the pre-announcement runup and the increase in call volume (or the increase in stock volume) are qualitatively similar.

5 Which Option Contracts Do Traders Prefer?

Our next task is to address which types of option are more favored by informed traders. The problem is similar to that modeled by Easley, O'Hara, and Srinivas (1998). In their model an informed trader chooses between the stock and options markets, so as to maximize expected returns and minimize trading costs. As they discuss, increasing the strike price of a call (even making the call out-of-the-money) has the effect of increasing the leverage and hence the incentive for the informed to use that option. Therefore, among option contracts, informed traders should prefer those with high leverage and high liquidity. OTM options offer higher leverage but are generally less liquid (with higher relative bid-ask spreads) than ATM options. But, if the expected price movements are large, the leverage effect should tend to dominate the liquidity effect, making OTM options an informed trader's instruments of choice. Similarly, to avoid paying a high option premium, an informed trader should prefer short-term over longer-term contracts, as the former offer higher leverage and are generally more liquid. Of course, the options' remaining lifetime should be long enough to cover the likely announcement date.

Once a moneyness-maturity combination is chosen, the investor can further select among many possible bullish strategies to achieve the goal. A partial list of these alternatives is summarized below:

- Buy a call
- Short a put
- Buy the stock and short a call
- Close a previous short call position
- Close a previous long put position
- Short a call with a higher strike price and buy a call with a lower strike price (the bullish call spread)

- Buy a put with a lower strike price and short a put with a higher strike price (the bullish put spread)
- Short a short-term call and long a longer-term call (a bullish calendar spread).

For our research design and due to data limitations, we cannot identify the true strategy behind every trade (is it to open or close a long or short position? is it a stand-alone position or part of a spread/combination strategy?). Instead, we can infer the trading direction and information from the observed aggregate activity for each moneyness-maturity option category. In what follows, we examine the relative trading activities in various types of option.

5.1 Implied volatility and option volume

We first study changes in implied volatility and option volume across moneyness and maturity categories, for both calls and puts and between the benchmark and pre-announcement periods. Table 3 displays the implied volatility and the number of contract traded for each put or call category. Among short-term calls, implied-volatility change is the largest for the OTM, followed by the ITM and ATM options. Further, the increase in OTM calls-implied volatility is almost twice as large as that in ATM calls-implied volatility. For example, the implied volatility increases by 17.8%, 8.8%, and 9.7% respectively based on short-term OTM, ATM, and ITM calls. All the implied-volatility increases are significant according to both a non-parametric test and the t-test. These increases in implied volatility suggest that investors pay a higher premium for call options during the pre-announcement period than during the benchmark period. This is particularly true for short-term OTM calls. While implied volatility increases for long-term calls as well, there does not seem to be any discernable difference across option moneyness categories. Further, the change in long-term calls-implied volatility is typically much smaller than in short-term calls-implied (e.g., the change is 7.8% based on long-term OTM calls, versus 17.8% based on short-term OTM calls). Therefore, although all call prices are sensitive to pending merger/takeover announcements, the short-term OTM calls are the most informative.

For short-term puts, implied volatility also increases prior to announcements: the changes are 8.2%, 11.2% and 13.0% for OTM, ATM and ITM puts, respectively. However, the difference in implied-volatility change between short-term OTM and ITM puts (4.8%) is much smaller than that between OTM and ITM calls (8.1%). Another noticeable result is that the change in implied volatility is larger for short-term OTM calls (17.8%) than for short-term ITM puts (13.0%). Thus, call option premiums go up more than their put option counterparts prior to takeovers.

Interestingly, for both calls and puts, most of the increase in trading activity occurs in contracts with less than two months to expiration. In fact, trading activity for long-term puts does not increase. Between short- and long-term calls, the change in option volume is significantly greater for short-term options (e.g., 166.0% increase versus 28.6% for OTM calls, and 252.8% versus 90.0% for ITM calls). This evidence suggests that the majority of traders is relatively confident that the announcement date will occur within two months.

Next, we examine the pattern of option volume change across moneyness categories. For both short- and long-term calls, the greatest percentage increase in volume occurs with the ITM options. Take short-term calls as an example, the number of OTM calls traded increases from 100 to 266 contracts, a 166.0% increase between the benchmark and pre-announcement periods. Yet, trading volume increases by 252.8% from 53 to 187 contracts for ITM calls. It is interesting to note that, although the increase in volume in percentage terms is the largest for ITM calls, the increase in number of contracts is the largest for OTM calls. One possible reason for ITM calls experiencing the highest percentage volume increase is that, as documented in the takeover literature and as shown in Table 1, stock prices tend to increase significantly prior to takeover announcements. Consequently, relatively more calls become in-the-money during the pre-announcement period. If the options exchange does not introduce call options with higher strike prices soon following the stock price run-up, there will be fewer OTM calls remaining for investors to trade.[11] Indeed, for

[11] In general, the CBOE does introduce new option contracts with higher or lower strikes after large stock price changes, but they usually do so after some observation time (to see if the stock price movement is permanent). Also, newly introduced contracts are generally associated with longer maturities (as short-term contracts may expire too soon).

some firms that experience large price run-up, we find fewer OTM calls available prior to takeover announcements. Thus, large stock-price run-ups tend to cause more calls to become ITM and more puts to become OTM during the pre-announcement period.

5.2 Buyer– versus seller–initiated option volume

Since the Berkeley Option Database does not have information on whether a trade is buyer- or seller-initiated, one must use intraday data to classify trades. To do this, we adopt an algorithm similar to the ones used by Lee and Ready (1991) for stock trades and by Vijh (1990), Amin and Lee (1997), and Easley, O'Hara, and Srinivas (1998) for option trades. Specifically, we assign a trade as a buy or a sell according to the following criteria:

- Any trade occurring below the then-current bid-ask midpoint is classified as a sell, and any trade above the midpoint a buy. For a seller-initiated trade, the transaction price can be in-between the bid and the bid-ask midpoint, or below the bid. Similarly, for a buyer-initiated trade, the trade price can be in-between the bid-ask midpoint and the ask, or above the ask.

- For each trade at the bid-ask midpoint, we compare the current and previous transaction prices to further classify the trade. If the current trade price is higher (lower) than its preceding trade price, it is classified as a buy (sell).

- Trades not meeting the above criteria are classified as cross-trades.

In Table 4, we present the cross-sectional averages of buyer-initiated and seller-initiated option volume, for both calls and puts of various moneyness-maturity combinations. For all calls, Table 4 reveals that the buyer-initiated volume increases from 152 to 383 contracts per day, a 152% increase from the benchmark to the pre-announcement period, while the seller-initiated changes from 166 to 398 contracts, a 140% increase.[12] Thus, both buy and sell activities intensify prior to takeover

[12]Note that the seller-initiated call volume is normally higher than the buyer-initiated. This is potentially due to the popular use of the covered call-writing strategy in which the investor sells short a call option for each share of the stock long. This strategy is often viewed as return-enhancing.

announcements. However, the increase in purchases is larger than in sells. For puts, the opposite is true: seller-initiated volume increases more than buyer-initiated volume. In this case, the purchase volume goes up by 79%, while the sale volume by 90%. In summary, prior to takeovers, activity pick-up in the options market is more often caused by bullish trading (i.e., more long positions in calls and more short positions in puts). If there were no information leakage about a takeover, one would expect the buyer- and seller-initiated volume to change by similar amounts. The significant bullish bias in increased trading activity prior to takeovers is again strong evidence of informed trading in the options market.

The increase in trading activity also differs across moneyness-maturity categories (for both calls and puts). For short-term OTM calls, buyer-initiated volume (in Table 4) increases by 202.6%, whereas seller-initiated volume goes up by 150%. This difference in volume change is significant at the 5% level based on both t-test and non-parametric test. For short-term ITM calls, the opposite is true: buyer-initiated volume increases by 255% but seller-initiated volume by 279%. Thus, a higher fraction of volume increase for short-term OTM (ITM) calls comes from buyer-initiated (seller-initiated) trades. Similarly, the increase in signed volume is significant for long-term calls of each moneyness. However, the magnitude of these volume-changes for long-term calls is far less than for short-term calls. This is true in terms of both percentage volume change and the number of contracts traded.

For puts, there is a similar pattern in buyer- and seller-initiated volume changes (Table 4). Short-term OTM puts also absorb most of the volume increase. In particular, for these puts, the buyer-initiated volume increases by 223.1% while the seller-initiated volume goes up by 200%. A likely reason is that while most traders are betting on the upside, at least some of them are in the mean time putting on a level of insurance by buying short-term OTM puts. Thus, while there is increased OTM call buying, there is simultaneous OTM put buying for insurance. On the other hand, for short-term ITM puts, seller-initiated volume increases more than buyer-initiated volume. This is again consistent with our earlier evidence of generally bullish trading prior to takeover announcements. Finally, long-term puts show little change in trading activity from the benchmark

to the pre-announcement period.

6 Trading Patterns across Targets

It can be argued that for different merger targets, the degree of difficulty in detecting informed trading can differ, depending on whether the options on these stocks are normally active or not, as well as whether the announced takeover premium is high or low. In this section, we examine this issue in detail.

6.1 Pre-announcement activities in active versus inactive options

We first divide the takeover sample firms into two groups of equal size based on their average call-option volume in the benchmark period. As seen from Table 5, for target stocks whose option contracts are normally inactive, their call options experience an average volume increase of 852% (from 57 to 543 contracts per firm per day) during the pre-announcement period, whereas for target firms with normally active options the average call-volume change is only 79% (from 737 to 1319 contracts per day). Furthermore, the volume increase for targets with normally inactive options is again concentrated in short-term calls.

Examining buyer- and seller-initiated call activity reveals similar patterns to those found in Table 4. As shown in Table 5, regardless of whether a stock's options are normally active or not, trading in OTM and ATM calls is predominately buyer-initiated while trading in ITM calls is mostly seller-initiated. Indeed, based on Table 5, it is much easier to detect informed trading when a stock's normal option-trading level is low. For some firms, the average number of contracts traded in the benchmark period is less than ten contracts per day, and the percentage call-volume increase during the pre-announcement period is extremely high.

6.2 Call volume and announcement-period returns

Next, we examine the association between pre-announcement signed-volume change and subsequent announcement-day return. Previous regression analysis has demonstrated that the increase in call volume is the largest for stocks with high announcement-day returns.

Table 6 presents call-option volume increases for two equal-size groups partitioned according to each target's abnormal announcement-day return. Interestingly, for securities with large announcement-day returns (from the close on date -1 to the close on date 1), there is an average call-volume increase of 223%, whereas for firms with small announcement-day returns there is an average call-volume increase of 71%. Classifying the direction of the activity as buyer- and seller-initiated as well as by moneyness and maturity categories reveals that trading activity is heavily concentrated in short-term OTM call options for securities with large abnormal announcement day returns. Further, there are more purchases than sales of short-term OTM calls. For instance, short-term OTM calls experience a 389% increase in buyer-initiated volume and a 297% increase in seller-initiated volume. Such increases also take place for firms with small announcement-day returns, but the magnitude of the volume change is much smaller. Overall, the increased trading activity in calls for securities which subsequently experience large announcement day returns is again suggestive of call trading activity foreshadowing the magnitude of subsequent price movements.[13]

7 Volume-Based Trading Strategies

Preceding analysis has demonstrated the relative informativeness of the options market. An additional approach to examine this issue is to consider trading strategies based on abnormal call volume versus abnormal stock volume. There are several advantages to such an approach. First, such trading strategies can directly benefit from the information contained in the options versus the underlying stock activities. Second, trading profitability serves as an economic measure of the

[13]We also experimented with partitions based on cumulative abnormal returns during [-1, +5], and find similar results.

information content of trading activity changes. We divide the trading analysis into two parts. In the first part, we apply the trading strategies only to those stocks and their options in our takeover sample. Of course, this in-sample trading analysis biases our results as such profits might not have been feasible *ex ante* for an uninformed trader. But, it does serve to further illustrate the relative informativeness of different markets. In the second part, we extend the analysis to cover all stocks with options traded on the CBOE (hence, *out of sample*). In that case, trading represents what should have been feasible even to an uninformed investor who can at least observe the trading volume information.

We follow a moving average trading rule similar to that used by Brock, Lakonishok, and LeBaron (1992) in their study of technical trading for the Dow Jones Industrial Average. According to the moving average trading rule, a buy signal is generated when the short-period moving average call-volume exceeds the long-period moving average call-volume by k%. For our analysis we use k=25, 200, and 500%, long-periods of 30, 60, and 100 days, and a five-day short-period window. The long-period volume calculation stops in the day prior to the short-term window. For the last day of the short-period window, the volume activity up until 2:00 p.m. (CST) is used to assess whether a buy signal is generated. If a buy signal is generated, all call options of a particular firm with maturities greater than the holding period are bought in equal quantity (e.g., 1 contract for each call) at the 3:00 p.m. price on the same day.[14] To avoid the impact of expiration-related activities, we exclude triggers on the day before and the day of option expiration. Once trades are executed, the positions are held for a fixed holding period of one, two, or four weeks. During the holding period, no trading signal is considered.

To examine the profitability of each trading rule considered, we adopt a uniform aggregation procedure. First, we calculate the average daily return to all call trades for a particular stock. Next, we obtain cross-sectional average of daily returns across firms which are held on each given day. The time-series average of daily returns, the corresponding standard error, and the total

[14]This is equivalent to holding an equal-weighted option portfolio. We also consider alternative implementations, e.g., trade one unit of at-the-money option only, etc. This issue is discussed in a later section on robustness issues.

number of triggers are reported. The results from alternative aggregation methods are discussed in a later section. Returns are calculated using two different methods. The first method considers transaction costs. In this case, calls are bought at the ask price on the first day and then sold at the bid price on the last day of the holding period. Trading costs to investors include the bid-ask spread, commissions, etc. For simplicity, we only take into account the bid-ask spread cost and refer to the resulting return as the profit after transaction costs. For the second method, calls are bought and sold at the average of the bid and ask prices, namely, the bid-ask mid-point. We refer to the return calculated using the bid-ask mid-point as the profit without transaction costs.

Trading profits are reported for three different periods: (1) the whole period from 150 days before to 250 days after the announcement ([-150, +250]), (2) the pre-announcement period ([-150, 0]), and (3) the post-announcement period ([+5, +250]). Recall our option sample spans from one year (250 trading days) before to one year after each announcement (or when the options are delisted from the CBOE, whichever comes first). Since the long-window for the three trading rules includes 30, 60 and 100 days, the option sample starts from 150 days before an announcement to ensure that all trading rules use the data from the same time period. This consideration guarantees that any difference in trading profit between two trading rules is not due to the difference in the data used.[15]

7.1 Call volume-based trading strategies

Panel A of Table 7 displays the trading profits for the whole period, with and without transaction costs. Without transaction costs, the returns are positive except for the trading rules requiring a 25% increase in volume with a one week holding period. Comparing profits across 30, 60 and 100-day long-period windows reveals that profits generally increase as the long-period window increases. With the 100-day long-period window, fewer trades are generated but the average profit of these trades is considerably lager than with the 30 and 60-day benchmark windows. Most importantly,

[15] We also implemented each trading rule by using all available option data, e.g., the sample starts from date -220 (-150) when the long-window is 30 (100) days. The results are qualitatively similar.

trading profitability is strongly increasing in the volume trigger level.[16] For instance, for the 100-day long-period and two-week holding period, daily trading profits per contract per firm are 0.55, 2.77 and 4.15%, respectively, for 25, 200 and 500% trigger rules. Based on the 200% and 500% volume triggers, the profits are generally largest for a two-week holding period. Standard errors for each profit number are reported in parentheses. They indicate that nearly all of the trading rules generate statistically significant profits, except for the 25% call-volume trigger with a one-week holding period. At the 500% call-volume trigger level and with the 100-day benchmark window, the strategies with one, two, and four-week holding periods earn economically significant daily returns of 2.88%, 4.15%, and 3.24%, respectively. Trading profits using the bid-ask midpoint prices are also generally increasing with the volume-based trigger level and the benchmark window period.

To see whether the majority of the trading profits occurs before the announcements, in Panel B of Table 7 we report trading profits (after transaction costs) separately for the pre- and post-announcement periods. It is shown that most trading profits for the entire sample period (as reported in Panel A) actually occur prior to the announcements. This is evident as returns are positive at all call-volume trigger levels and for all holding periods, while returns are mostly negative or close to zero for the post-announcement periods. In addition, higher volume triggers do not seem to produce larger trading profits for the post-announcement periods. Since most non-public information is revealed at the announcement date, option trading following an announcement is less likely to be motivated by information and is thus less profitable on average.

Overall, the fact that trading profits increase with the level of call-volume change required to trigger a buy signal confirms our earlier conclusion that increased call-option activity is often associated with informed trading. The more a stock's option activity picks up, the more likely someone is trading on information. Otherwise, it would not be true that the higher the call-volume increase necessary for a buy signal, the stronger the relationship to future price movements.

[16] The results (not displayed) based on volume triggers of 50% and 100% yield a similar pattern as for the ones displayed.

7.2 Trading profits using different securities

The preceding subsection concerns only strategies of buying all available calls once a given buy signal is generated. Clearly, it is possible that using different option contracts as a trading instrument results in different profitability even though the same information may be used. The relative desirability of an option as an informed trading instrument may depend on several factors. First, options of different moneyness and maturities offer distinct exposures to the underlying stock movements. Among other things, they differ in option delta and gamma. Given positive information about a stock's future, one will generally get the highest returns by buying short-term OTM calls. Second, liquidity and transaction costs are important considerations. For instance, OTM options have an average bid-ask spread of 26.6%, as compared to a percentage bid-ask spread of 9.4% for ITM calls.[17] Thus, while offering more leverage, OTM options are harder and more costly to trade. In addition to the option contracts, one can also use the underlying stock to trade on information, where option-volume changes are still the basis for buy and sell triggers. The stock offers no leverage, but usually has higher liquidity.

To examine these issues empirically, in Table 8 we report profits in the pre-announcement period from trading OTM, ATM, and ITM calls as well as the underlying stock. Regardless of the instrument used, all trades on the same target are triggered by the same signal and hence the number of trades for each given target should be roughly the same. The only situations where a difference may occur across the instruments are when there are not call options traded within a particular moneyness range. For Table 8, all return calculations are adjusted for the bid-ask spread,[18] and the average call volume over a 100-day benchmark window is used as the basis to determine a buy trigger.[19] It shows that despite higher transaction costs to OTM options, they

[17] The average percentage bid-ask spreads are taken from the pre-announcement period prior to takeovers for short-term options.

[18] For the stocks, we do not have the closing bid and ask prices. We account for the cost of the spread by calculating the return for trades at the closing prices and then deduct an average round-trip bid-ask spread of 1.20%. This number is based on results of Huang and Stoll (1996) who report that the average spread for a representative sample of NYSE firms is \$0.26 with an average price of \$21.6. These calculations are thus only indicative of the actual trading costs.

[19] Results for 30- and 60-day benchmark windows are similar, but not reported to save space.

produce profits that are in some cases twice as large as those displayed in Panel B of Table 7 (where one contract of each call on the underlying stock is bought once a buy signal is generated). More importantly, with a given trading rule and a holding period, the profits are the highest when one trades OTM calls, followed by ATM and then ITM calls. The profitability is the lowest if one uses the underlying stock as a trading instrument. As an example, fix the holding period to be one week and take the 100-day volume benchmark window, so that whenever the current moving-average call volume is 500% (the trigger level) higher than the benchmark period's average call volume, a buy signal is generated. Trading profits from using OTM, ATM, ITM calls and the underlying stock are 11.7%, 4.52%, 2.60% and 0.64%, respectively.

Thus, despite the larger percentage bid-ask spreads in the options market (in particular, for OTM options), the trading profits based on signals generated by call-volume changes are largest in the options market (especially when using OTM calls). With the same trading rule, the daily return from using OTM calls is about 18 times the return obtainable by buying the underlying stock. These results highlight the incentives to trade options, the leverage effect, and hence the role played by the options market in the price discovery process. Still, without knowing whether takeover events will occur, it is also more risky to trade options than the underlying stock.

7.3 Stock volume-based trading strategies

The preceding analysis has established that it is highly profitable to buy calls whenever the moving-average call-option volume exceeds benchmark norms by a certain trigger threshold; Furthermore, the higher the volume trigger level, the more precise it detects informed trading and hence the more profitable the call volume-based strategy. Does stock volume contain information of the same or better precision? While our earlier exercise has answered this question, it is of interest to examine the profitability of stock volume-based trading within the takeover sample firms. Specifically, we consider the exact same trading strategies as those implemented in Table 7 (i.e., there is a volume benchmark period and a buy-trigger level), except that the underlying stock-volume change is used to decide when a buy signal is triggered. For comparison, we buy all available calls once a buy

signal is generated. Clearly, the more informative a security market about future events of the concerned firm, the more profitable the strategies based on that market's activities.

For the pre-announcement period, Table 9 displays the average daily returns from trading on stock-volume activity. As shown in Figure 1, in percentage terms stock volume generally does not increase as much as call volume. Accordingly, we examine various trading rules with finer and lower stock-volume triggers (i.e., 15%, 25%, 50%, 75%, 100%, 200%, and 500%). This table reveals the following. First, unlike call volume-based strategies, trading profits are not monotonically increasing with the stock-volume trigger level. Thus, consistent with the regression results in Table 4, higher stock volume does not necessarily suggest any significant positive event pending, whereas call-volume increases do. Second, the trading profits generated by stock-volume signals is generally much lower in magnitude than those by option-volume signals. For the 30-day benchmark window and one-week holding period, daily returns based on stock volume are 0.27%, 0.66% and -0.75%, respectively, at buy trigger levels of 25%, 200% and 500%. In contrast, the corresponding daily returns are 0.15%, 0.97%, and 5.63% if the buy signals are based on call volume and the same volume trigger levels are used (Panel B of Table 7).

The difference in returns is particularly pronounced for trigger rules based on large volume increases. For example, the best performance based on stock-volume signals is obtained with the 100-day benchmark window and 200% trigger rule: the average daily returns are 1.84%, 1.97%, and 0.65% respectively for the 1, 2, and 4-week holding periods, with a total of 72, 61, and 55 trades. On the other hand, the performance based on call volume is far better even with similar numbers of trades. With the 100-day benchmark window and 500% call-volume trigger rule, the numbers of trades are 51, 41, and 35, and the average daily returns are 6.93%, 7.49%, and 6.05%, respectively for the 1, 2 and 4-week holding periods. These call volume-based returns are indeed many times as large as the stock volume-based counterparts. It should be noted that in terms of the risk, leverage level and trading frequency, the two types of volume strategy are similar (both use all available calls for the same lengths of time). The only possible cause for the return differences lies in the quality of the volume signals. The options market is truly more informative.

8 Option Trading Activity and Subsequent Stock Movements: Out of Sample

Does the above conclusion regarding the relative informativeness of option versus stock volume hold more generally, even out of the takeover sample? In the preceding exercise, the question was that conditional on an actual takeover announcement, did the prior trading activities signal such an event? A benefit from the in-sample analysis is that as researchers, we could isolate this type of truly significant event from other corporate events, non-events, groundless rumors or pure noises. Once we expand the sample to include all firms with options traded on the CBOE, however, a trader implementing any volume-based strategy is bound to generate false buy signals from time to time. Accordingly, returns from trading out of the takeover sample must be significantly lower. Nonetheless, given that our purpose is to understand the relative attractiveness of the options versus the stock market to informed traders, we can focus on the relative profitability of trading, out of sample, on option versus stock volume.

The option universe is constructed as follows. All firms with at least one year of intraday option data available on the Berkeley Option Database between 1986 and 1994 are included. These firms are then matched to the CRSP database where daily stock price and volume information is obtained. From 1986 through 1994, there are 365 firms meeting these criteria.[20] Again, we use the same aggregation procedures as in previous sections.

Table 10 reports the daily returns, both with and without transaction costs, for the moving-average volume-based trading rules involving all calls. Similar to the in-sample results in Table 7, trading profits out of sample are generally increasing in the trigger volume level. With the 60-day benchmark window and one-week holding period, average daily returns without transaction costs are 0.58%, 0.67% and 1.38% respectively at the 25%, 200% and 500% call-volume trigger levels. After transaction costs, trading profits for most strategies are negative and significant. The only positive return after transaction costs is with the 100-day long-period volume window and the 500%

[20] By construction, the sample of all firms also contains those in the takeover sample.

trigger rule. This evidence suggests that extreme call activity precedes significant future stock price movements, and only trading in the presence of such extreme call activities can one generate enough profits to overcome the bid-ask spread costs.

Table 11 reports after-transaction-costs daily returns from trading on call-volume signals and using only OTM, ATM, or ITM calls, or the underlying stock. After accounting for transaction costs, trading profits are in many cases negative regardless of the moneyness of the call contracts used. However, when the underlying stock is used as the trading instrument, the after-transaction-costs returns are positive (though small in magnitude) for all call volume-based trading rules. It is noted that the loss is generally the largest when trading OTM calls, followed by ATM and ITM calls. Because percentage bid-ask spreads are larger for OTM options, the spreads lead to heavy losses unless share prices increase by a sufficiently large margin. Transaction costs for stocks are lower, making it possible to still yield a positive return even after transaction costs.

In addition, with the 500% volume trigger and both the two and four-week holding periods, after-transaction-costs daily returns are positive when trading OTM calls (0.17% and 0.66% respectively with the two and four-week holding periods), or when trading ATM calls (0.38% and 0.41%). In comparison, when the underlying stock is used for trading, the corresponding daily returns are only 0.05% and 0.03%. Thus, one should favor calls more than the underlying stock when choosing an instrument to mimic possibly informed trading. When using either OTM or ATM calls, a trader's daily returns (after transaction costs) increase significantly as the holding period goes from one week to four weeks. A possible reason for this pattern is that for these calls the percentage bid-ask spread is usually high. Consequently, the longer one can hold onto an already established position, the more the transaction costs can be spread over a long period of time, making the average daily returns higher.

The last test focuses on trading profitability of stock volume-based strategies applied to the full sample of firms. In Table 12, we report the results based on a 100-day volume benchmark window,

with and without transaction costs.[21] The average daily returns after transaction costs are negative for all trading rules. These negative returns are similar to the findings by Bessembinder and Chan (1997) for moving-average trading rules applied to the Dow Jones Industrial Average. In Table 12, the variation in losses is quite small across the different trigger rules. For example, the daily returns are -1.25%, -1.32% and -1.53%, respectively, for 15%, 100% and 500% volume triggers. Returns from trading at the bid-ask mid-points are positive and significant, but consistently less than those from call volume-based strategies. For instance, if a buy signal is generated whenever current moving-average stock volume is 500% higher than its benchmark level, the average daily return is 0.30% for a one week holding period. On the other hand, when stock volume is replaced by call volume to generate buy signals, the corresponding daily return is 1.30% (see Table 10).

In sum, these out-of-sample comparisons between call and stock volume-based trading rules reveal similar inferences to those obtained from the takeover sample alone. Abnormally high call-option activity generally signals more information about pending market-moving events than stock-market activity does. This suggests that the relative proportion of informed trading in the options market is larger than in the underlying stock market.

The preceding analyses have used the volume of all calls to generate a buy signal. One possibility for further refinement of the trading strategies is to use only buyer-initiated call volume as the basis. To the extent that informed trading ahead of positive news is more accurately reflected by buyer-initiated call trading, trading rules with signed volume may be more profitable. To investigate this issue, we allow a buy signal to be generated whenever (a) short-term buyer-initiated call volume exceeds its benchmark period's counterpart by k% (k=25, 200, and 500), and (b) the short-term buyer-initiated call volume exceeds the short-term seller-initiated call volume by 10%. With the 30-day volume benchmark window, the average daily returns based on the buyer-initiated call-volume triggers are only slightly higher than those based on total call volume (as in Table 10). With the 60- and 100-day benchmark periods, the buyer-initiated call-volume trading strategies

[21] The results with 30- and 60-day benchmark windows reveal similar patterns and are omitted to conserve space.

do slightly better than the total-volume-based strategies at the 25% and 200% trigger levels, but slightly worse at the 500% trigger level.[22] For example, with the 100-day benchmark period and at the 25% volume trigger, the buyer-initiated volume trading rule generates (before transaction costs) daily returns of 0.82%, 0.56%, and 0.45% respectively for the one, two, and four-week holding periods, as compared to 0.55%, 0.44%, and 0.38% based on total call volume (as in Table 10). With the 100-day benchmark period but at the 500% volume trigger, the corresponding daily returns based on the buyer-initiated call volume change to 1.14%, 0.81%, and 0.46%, as compared to 1.30%, 1.07%, and 0.83% based on total call volume. Similar results are found when the buyer-initiated call volume is required to exceed its seller-initiated counterpart by 50%. Overall, trading results based on buyer-initiated call volume are similar to those based on total call volume.

9 Robustness of Empirical Results

Many of the analyses conducted in this paper require multiple choices in calculation, some of which have already been discussed. To examine the robustness issues further, below we briefly discuss several additional points.

Section 5.2 studies changes in buyer- and seller-initiated volume between the benchmark and pre-announcement periods, and describes the trade classification scheme used. When a trade occurs at the mid-point of the bid and ask (e.g., a cross-trade), we use the tick rule to further classify the trade by comparing the current trade price with the previous trade price. There are at least two alternatives for the tick rule test. First, trades can be classified as crosses if they are at the mid-point of the bid and ask. Another alternative to further classify cross-trades is to compare the current trade price (p_t) with the quoted price posted prior to the prevailing quote (q_{t-1}). We investigate both of these alternatives and find that they lead to similar results as the ones reported earlier.

For our trading rule tests, the aggregation method for calculating returns is to take the cross-

[22] The results are not reported here but are available upon request.

sectional average profit on each day first and then obtain the time-series average. We also consider an alternative aggregation method: calculate the time-series average of daily returns first for each firm, and then obtain the cross-sectional average return for each day. This aggregation method yields results that are qualitatively similar to those reported in Tables 7, and all patterns of the trading profits discussed hold. Take the 30-day benchmark period and one-week holding period as an example. Using the first aggregation method, daily trading profits for the pre-announcement period are 0.15%, 0.97% and 5.63%, respectively, at the 25%, 200% and 500% triggers (see Panel B of Table 7). With the second aggregation method, the returns are 0.15%, 1.17% and 4.70%.

In addition, we consider the impact of the market crash on our results. Specifically, we exclude the two crash periods from the sample, October–November 1987 and October 1989, and recalculate returns for all trading rules and all holding periods. The results are similar to those reported in Tables 7–10. Further, we repeat the analysis in Table 7 by using the average volume over the most recent ten days, instead of the most recent five days, to stand for the current moving-average volume. Again, the results are qualitatively similar.

Finally, recall that when a buy signal is generated, all call-options of a particular firm with maturities greater than the holding period are bought in equal quantities. This implementation implicitly assumes that we hold an equally-weighted option portfolio upon achieving a buy signal. Since each option included in the portfolio is unique in its maturity and strike price, it is natural to ask how large the trading profits will be if one trades only the most liquid option contract. In general, short-term ATM options are the most active and most liquid. To answer this question, we recalculate the profits for each trading rule by assuming, whenever a buy signal is triggered, only a position in the ATM call with about 30 days to expiration. We find that the resulting returns under the various trading strategies reveal similar patterns but are slightly higher than those reported in Tables 8 and 11 under the heading "Trade (All) ATM Calls". In sum, the main inferences drawn from the trading rules as well as those from other analyses are unaltered by alternative specifications.

10 Concluding Remarks

We have analyzed pre-takeover-announcement trading in the options versus stock markets. Overall, we have found that while abnormal trading generally occurs in both the options and stock markets prior to takeover announcements, activity increases on the options market are much more pronounced than on the underlying stock market; Higher takeover premiums tend to be preceded by heavier call-option trading during the pre-announcement period; The trading direction in the options also anticipates future stock-price movements. For example, five days prior to a merger announcement the percentage increase in call volume is over four times as large as that experienced in the underlying stock and almost twice as large as that experienced in puts. Such systematic abnormal trading patterns are hardly random noises. Indeed, while the pre-announcement stock-volume changes provide no significant information about future takeover surprises, changes in pre-announcement call volume are significantly correlated with announcement-day returns. Thus, call-option volume, not stock volume, is more informative of future merger-related price surprises. Between the options and the stock market, the former is more conducive to informed trading.

The moneyness and maturity of traders' favorite options also provide information about pending events. Prior to announcements, implied volatility and buying activity relative to selling are the highest in the OTM options (with the highest leverage). Additionally, most of the increase in pre-announcement option activity is concentrated in options with less than two months to expiration. It suggests that those making the trades are relatively certain that an announcement will occur and will occur soon. While put volume also increases prior to announcements, the majority of those trades are on the sell side (hence also bullish).

To examine the relation between option volume and subsequent price movements, we have implemented moving-average trading rules. Buy signals are generated whenever call volume on a stock surpasses a threshold level. Trading profits so determined are increasing in the level of the threshold. In other words, the larger the increase in call volume it takes to trigger a buy, the more likely that a truly positive signal is picked up by the filter. We apply the same trading rules to

stock volume, but find that increasing levels of stock volume do not convey information regarding future price movements. This exercise has further confirmed our findings that the options market is more efficient for price discovery when informational asymmetry is large.

Our findings have broad implications to the market for corporate control and the monitoring of insider trading. Schwert (1996) concludes that bidding firms generally cannot distinguish whether increases in stock price for takeover targets are caused by competing bidders or leaks of proprietary information. This suggests that the cost of insider trading is borne by the bidders in terms of a higher takeover premium. Yet, competing bidders should not purchase options since they contain no voting rights. Our results indicate that if information has leaked about a pending takeover this information is likely to be revealed in the options market first.

Our analysis is also related to the optimal enforcement of illegal insider trading. While we do not investigate whether the evidence of informed trading is driven by illegal insider trading, one might assume that at least some of the information is illegal in nature. As modeled by DeMarzo, Fishman, and Hagerty (1998), investigation of insider trading activity is costly and regulators should focus on the most cost-effective enforcement mechanism. If a relatively large and detectable portion of trading in the options market is driven by insiders, then it may be optimal for regulators to expend relatively more monitoring efforts on the options market. To the extent that market makers do not fully hedge their positions or are only approximately hedged for small price movements, illegal insider trading can be quite costly to option market makers. Thus, there seems to be a recent movement by the CBOE itself to investigate large volume activities prior to takeovers. Yet, there is a whole industry of speculators who observe option market activity for signs of insider trading. The elimination of insider trading may also hamper the trading activities of those speculators who mimic informed trading. Consequently, stock and option prices may become less informative and the markets less efficient. From a market designer's perspective, our evidence shows that it matters what type of security market is available to investors.

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