Charles Cao
Smeal College of Business, Pennsylvania State University and CCFR

Zhiwu Chen
School of Management, Yale University

John M. Griffin
McCombs School of Business, University of Texas at Austin

Informational Content of Option Volume Prior to Takeovers*

The capital-allocation role of financial markets rests 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 markets are the most conducive to price discovery and information incorporation? To investigate these issues, this paper focuses on a particular type of event, merger/takeover announcements, and examines the relative effectiveness of the stock market versus the options market for information and price discovery.

* Research support from the Smeal College of Business at Pennsylvania State University (Cao) is greatefully acknowledged. We want to thank Heejoon Ahn, Clifford Ball, Hank Bessembinder, Arturo Bris, Jeff Coles, Ian Domowitz, Ron Giammarino, Frank Hatheway, Robert Heinkel, Bill Kracaw, Kai Li, Mike Lemmon, Ron Masulis, Grant McQueen, Harold Mulherin, Allen Poteshman, Chester Spatt, Hans Stoll, René Stulz, Avanidhar Subrahmanyam, Dimitrios Vayanos, and especially the editor, Albert Madansky, and the referee for helpful comments. We are also grateful to seminar participants at the American Finance Association Meetings, Arizona State University, the University of British Columbia, the Utah Winter Finance Conference, Vanderbilt University, Western Finance Association Meetings, and Yale University. Any remaining errors are our responsibility alone. Contact the corresponding author, Charles Cao, at charles@loki.smeal.psu.edu.

(*Journal of Business*, 2005, vol. 78, no. 3)

0021-9398/2005/7803-0012$10.00

Which market attracts informed investors prior to extreme informational events? We examine the information embedded in the stock and option markets prior to takeover announcements. Normally, buyer-seller initiated stock volume imbalances are predictors of next-day stock returns and option volume is uninformative. However, prior to takeover announcements, call-volume imbalances are strongly related to next-day stock returns. Cross-sectional analysis shows that takeover targets with the largest preannouncement call-imbalance increases experience the highest announcement-day returns. These findings suggest that, with pending extreme informational events, the options market plays an important role in price discovery.

Takeover announcements are ideal events for studying information discovery in the security price formation process. First, unlike other corporate events, takeovers involve a change of control and usually come with large, immediately realizable price premiums, so an informational advantage can be significant and the potential reward, if coupled with the right trading instrument, can be extreme. Given the value of such information, there is a substantial incentive for one to trade, which can lead to heightened informed trading ahead of the event. The question is: ahead of such events, which market is more informative? A large body of literature examines lead-lag relations between the underlying stock market and options market in general. Examples include, but not limited to, Anthony (1988), Stephan and Whaley (1990), Vijh (1990), Easley, O'Hara, and Srinivas (1998), Chan, Chung, and Fong (2002), and Pan and Poteshman (2003). In related work, Mayhew, Sarin, and Shastri (1995) and Kumar, Sarin, and Shastri (1998) find that stocks with options traded on them generally have greater price efficiency. In this study, we focus on a significant informational event (e.g., takeover announcements) around which the information asymmetry is expected to be large. We test the hypothesis that, in the presence of pending extreme informational events, the options market displaces the stock market as the primary place of informed trading and price discovery.

Unlike prescheduled earnings announcements, takeover announcements are not planned; even the fact that such an announcement is pending is not publicly known. This is an important difference, because in the case of prescheduled earnings announcements, certain firms are known to have a history of consistently beating analyst forecasts and hence some traders make speculative bets, even if they have no superior information. In that sense, it is hard to tell whether increased trading prior to earnings announcements is based on information or simply speculation.[1] In contrast, abnormal pretakeover-announcement trading is likely to be started by traders who possess material information. Therefore, such events are ideal for studying which market tends to be the primary choice of informed traders and, hence, more conductive to information discovery.

In time-series analysis of our takeover target firms, we find substantial evidence of informed option trading prior to takeover announcements. Preannouncement call option volume imbalance (e.g., buyer-seller initiated call volume scaled by total volume) is highly predictive of the pending takeover, whereas future stock returns are not as sensitive to

1. Amin and Lee (1997) examine options trading surrounding earnings announcements. Skinner (1997) points out that, since approximate earnings announcement dates are known a priori, it is not clear what fraction of the increase in preannouncement trading is due to the presence of informed traders.

increases in share volume imbalance. After controlling for the contemporaneous relation between imbalances and returns, lagged call imbalances are still related to future returns but lagged share imbalances are not. Thus, ahead of takeover announcements, call imbalances are a better indicator of future event-day outcomes. However, during normal periods for our takeover sample, stock imbalances are the only variable informative of next-day returns. The results of our cross-sectional analysis suggest that the higher the preannouncement call (put) imbalance increases (decreases), the higher the takeover premiums.

The moneyness and maturity of traders' favorite options also provide information about pending events. Prior to announcements, buying activity is highest in the short-term out-of-the-money call options (with the highest leverage). It suggests that those making the trades are relatively certain that an announcement will occur and occur soon. We find no evidence that postannouncement option volume imbalances foreshadow the ultimate outcome of takeover (e.g., success or failure). We also confirm that these findings, like the time-series and cross-sectional results, are not sensitive to the exclusion of options with less than 30 days (or 7 days) to maturity. Therefore, ahead of a major announcement when information asymmetry is severe, the options market plays a more important role than the stock market, whereas during normal times the stock market seems to be the primary information-discovery place.

Finally, we examine the validity of our conclusion outside the takeover sample. In our out-of-sample exercise, all firms that had options traded on the Chicago Board of Options Exchange (CBOE) are included, and our goal is to gauge the economic significance and informational content of call and stock volume. Call net-buy imbalances coupled with extremely large increases in call volume lead to significantly high future returns. On the other hand, stock net-buy imbalances together with extreme increases in share volume are followed by lower returns. An implication of our results is that the options market can be particularly informative ahead of material events, while the stock market may be more suitable for disseminating normal information flow.

In addition to the microstructure literature, our paper is related to the existing literature on insider trading in the stock market prior to takeover announcements. Meulbroek (1992) examines unreported insider trades that were subsequently prosecuted by the Security and Exchange Commission (SEC) and finds that inside traders do use options and warrants to take advantage of their insider information. Among all insider trading episodes where exchange-traded options existed, inside traders employed options in 50% of these episodes. Yet, focusing on prosecuted insider trading is only a partial solution, as not all insider trading is detected by the SEC. The focus of our paper is on the price-discovery aspect of the markets, where informed traders are not necessarily insiders or investors who obtained inside information illegally.

Rather, we say trading is "informed" if its direction foreshadows subsequent price movements.[2] One may extract "information" legally by employing, for example, merger prediction models based on either business knowledge, economic fundamentals, or market trading activities.

In the literature on corporate control, the research focus generally has been on the determinants of takeover activity and who receives the takeover gains (e.g., Jensen and Ruback 1983; Lang, Stulz, and Walkling 1989; Mitchell and Mulherin 1996). Several studies find large increases in preannouncement stock price and volume (e.g., Keown and Pinkerton 1981; Jarrell and Poulsen 1989). This paper reveals that such increases in volume are much more severe in the options market and are driven by information-based trades.

Our paper extends existing literature in several ways. We provide a comprehensive examination of the relation among option volume imbalance, stock volume imbalance, and stock return for target firms prior to takeover announcements, when information asymmetry is expected to be large. Next, we examine the relation between preannouncement changes in stock and call volume imbalances and subsequent announcement-day abnormal returns. Further, we perform a matched sample comparison by comparing the imbalance-return relation between target firms with and without options listed; we test the hypothesis that, in the presence of pending extreme informational events, the options market displaces the stock market as the primary place of informed trading and price discovery. Finally, by performing out-of-sample tests and examining all firms with options listed, we investigate whether abnormal option imbalances and volume are related to future stock return in general.

The paper is organized as follows. Section I develops testable hypotheses and discusses insider trading regulation. Section II describes the data. In Sections III and IV, we present evidence of differential information embedded in option and stock imbalances. Section V examines the robustness of our findings to excluding short-term options, and Section VI discusses out-of-sample applications. Concluding remarks are provided in Section VII.

I. Alternative Trading Venues for Informed Traders

The idea that the options market may provide a lower-cost, more effective venue for informed trading can be traced back to Black (1975). He argues that an investor can get more leverage for each dollar invested in the options market. 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

2. In most microstructure models, a trader is "informed" if and only if his trades tend to foreshadow subsequent price changes.

comes with a specifically limited risk, whereas the leverage provided by a conventional loan or 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 be replicated by combining the underlying stock 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 sales, and capital constraints) are abundant, making option nonredundant. For instance, Back (1993) shows that, with asymmetric information, option and stock volumes covey different information and it is not possible to replicate an option with the underlying stock and a risk-free asset. These features favoring informed trading in the options market lead to our first hypothesis.

Hypothesis 1 (H1). Prior to takeover announcements, the option volume contains information regarding subsequent price movements.

A rejection of H1 could be driven by either an absence of informed trading in general or that it occurs only in the stock market. In addition to the preceding reasons for favoring the options market, several other features of the stock and options markets could favor either security. For corporate insiders, the enforcement of insider trading laws can potentially affect the market choice. Insider trading laws historically have applied differently to stocks and options. While Rule 10b-5 of the 1934 Security Exchange Act outlaws illegal insider trading in any security, the courts have applied the law to the options market only sporadically. The subsequent lack of enforcement of insider trading in options led Congress to elevate option contract trading on nonpublic information on the same level as trading in the stock market in Section 20d of the Insider Trading Sanctions Act (ITSA) of 1984. The SEC also indicated a willingness to prosecute insiders trading in options subsequent to ITSA, it is unclear whether insiders still perceive a looser standard of monitoring applied to the options market.

In addition, the SEC's ability to detect insider trading may vary across markets, depending on the market depth. It may be easier to detect illegal insider trading in the options market, as many contracts are thinly traded. Options are also generally associated with higher proportional transaction costs and less liquidity. Easley et al. (1998) model the constraints faced by the informed trader. Informed traders choose across market instruments to equalize profits. They argue that, as long as at least some informed traders choose to trade in the options market, then option trades will carry more information than stock trades. If options are used only for liquidity-based traders or speculators, then there is no reason for option volume to be more informative. These issues lead to the following hypothesis.

Hypothesis 2 (H2). Option volume is more informative than stock volume, prior to takeover announcements.

Because a relatively higher proportion of informed traders may be in the market, one might expect the information content of trading volume to be particularly high prior to corporate takeovers. This relation may differ during normal periods (with no pending informational events). This leads to our last hypothesis.

Hypothesis 3 (H3). Option volume is more informative than stock volume, even during normal periods, with no pending takeover announcement.

A rejection of H3 can be due to (1) no information in volume in either market or (2) stock volume conveying relatively more information than option volume. As discussed, this hypothesis, like H1 and H2, can have rational explanations both for them and their alternatives. Thus, it is an empirical question as to which market is more conducive to information revelation and price discovery.

To test these hypotheses it would be best if we had the precise motivation behind the trades. While such analysis is not feasible here, using trade classification algorithms, we are able to assign stock and option volume as buyer or seller initiated. Easley et al. (1998) show how this directional volume is more informative than raw volume, because signed volume provides important information about the motivation of the trade (bullish or bearish). To test these hypotheses, we use buyer-seller initiated volume scaled by total volume, as this provides more information about the nature of the activity in the respective markets.

II. Sample Selection and Preliminaries

Our takeover sample consists of all firms that were merger or tender-offer targets and had options listed on the Chicago Board Options Exchange between 1986 and 1994. Takeover announcements are first identified by the Security Data Corporation (SDC) database. Following Schwert (1996), we define the announcement day as the first day an official bid is received. The announcement day is verified by finding the first newspaper or online news indicating the terms of the acquisition on the Lexis/Nexis or Dow Jones news retrieval service. To ensure that the announcements are original, we examine only target firms that had received no other offers in the previous year.

Intraday option prices and volume are obtained from the Berkeley Options Database (BODB), while daily stock prices, volume, dividend, and split information are from the Center for Research in Security Prices (CRSP). Intraday stock trade and quote data are from the 1986–92 Institute for the Study of Security Markets (ISSM) transactions files and the 1993–94 Trade and Quote (TAQ) database distributed by the New York Stock Exchange. Firms are required to have at least 200 trading days of valid preannouncement option and stock data. Our final sample consists of 78 successful and unsuccessful takeover targets and is tilted toward large target firms.

We divide the option data into several moneyness and maturity categories for which the empirical results are reported. By convention, a call-option is said to be at-the-money (ATM) if $S/K \in (0.95, 1.05)$; out-of-the-money (OTM) if $S/K \geq 0.95$; and in-the-money (ITM) if $S/K \geq 1.05$, where S is the stock price and K the strike price. An option is said to be short term (long term) if it has less (greater) than 2 months to expiration. Finally, we define the announcement date as date 0; the period from trading day -200 to -100 as the benchmark period; and the period from trading day -30 to -1 as the preannouncement period.

To appreciate the informational content of option and stock volume, we examine buyer- and seller-initiated volume. The BODB, ISSM, and TAQ have no information on whether a trade is buyer or seller initiated, one must use intraday trade and quote data to classify trades. 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 et al. (1998) for option trades. Specifically, we assign a trade as a buy (sell) if it occurs above (below) the bid-ask midpoint. For trades executed at the bid-ask midpoints, we classify the trade as a buy (sell) if its trade price is higher (lower) than its preceding price. All other trades are classified as cross-trades and excluded.

Table 1 provides summary statistics of the trades prior to takeover announcements, including raw option volume, volume imbalance (the difference between buyer- and seller-initiated volume divided by the average volume over the benchmark period), bid-ask spreads, price, and underlying stock volume and imbalance. For a given firm, we calculate the daily average of each variable over the benchmark and preannouncement periods. We then obtain the cross-sectional average of the variable across firms.

The average daily share volume increases by 36.8%, from 250,000 in the benchmark period to 342,000 shares in the preannouncement period. There are 402 call contracts traded per firm per day on average in the benchmark period and 936 contracts in the preannouncement period, an increase of 132.8%. Recall that each option contract corresponds to 100 underlying shares. Based on this convention ratio, the daily call volume is 15.6% of stock volume in the benchmark period but increases to 59.9% of the underlying stock's daily volume in the preannouncement period. In unreported results, we find that the correlation between stock volume change and call volume change is 0.38 in the benchmark period and 0.52 in the preannouncement period. From the benchmark to the preannouncement period, puts experience a smaller increase in trading activity. As a result, the average put/call ratio decreases by 22.8%.

TABLE 1 Summary Statistics of Volume and Price for Calls, Puts, and the Underlying Stocks during the Benchmark and Preannouncement Period

Variable	Absolute [−200, −100]	[−30, −1]	Change	% Change
Calls				
No. of contracts (in 100 shares)	402	936	534	1328*†
No. of contracts as a % of stock Volume during [−200, −100]	15.6	59.9	44.3	283.9*†
Volume imbalance (%)	−4.83	5.70	10.53*†	
Bid-ask spread ($)	.38	.40	.02	5.2
Price ($)	2.33	2.53	.20	8.6*†
Puts				
No. of contracts (in 100 shares)	120	212	92	76.6*†
No. of contracts as a % of stock Volume during [−200, −100]	5.5	20.8	15.3	278.2*†
Volume imbalance (%)	−6.73	−12.48	−5.75	
Bid-ask spread ($)	.38	.40	.02	9.2*†
Price ($)	2.28	2.49	.21	9.2*†
Put/call ratio (%)	28.9	22.3	6.6	−22.8*†
Stocks				
Volume (in 100 shares)	2,500	3,420	920	36.8*†
Volume imbalance (%)	.30	6.71	6.41*†	
Cumulative abnormal return (%)	9.56	12.92		

NOTE.—This table presents the cross-sectional averages across firms of the daily call (or put) volume, option volume as a percentage of stock volume, volume imbalance, bid-ask spread, and price of the stock daily volume, volume imbalance, and cumulative abnormal return for the underlying stock. For each type security and each day, the imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period [−200, −100]. The put/call ratio is the daily average of the number of puts traded relative to the number of calls. Summary statistics are reported for the benchmark period [−200, −100] and the preannouncement period [−30, −1]. The null hypothesis of no difference in means (or medians) between the benchmark and preannouncement periods is tested by using the t-test (or the nonparametric Wilcoxon test), where * and † indicate significance at the 5% level using the t-test and nonparametric Wilcoxon test. All tests are based on percentage changes, except for the volume imbalance. The sample is 78 takeover targets with options listed on the CBOE from 1986 through 1994.

In addition to average volume, we also use each security type's median volume to measure trading activity and make similar inferences. Overall, the stock experiences the greatest increase in trading volume in absolute terms. However, relative to each respective security's benchmark level, call options experience the largest increase.

In figure 1, we plot the respective time-series of call, put, and stock volumes from date −100 to −1. For each security type and given date, the cross-sectional average volume is scaled by the average daily volume of that security in the benchmark period. It is noted that each stock, call, and put volumes begin to increase around date-30. Again, the relative volume increase is much greater for options (particularly calls) than for

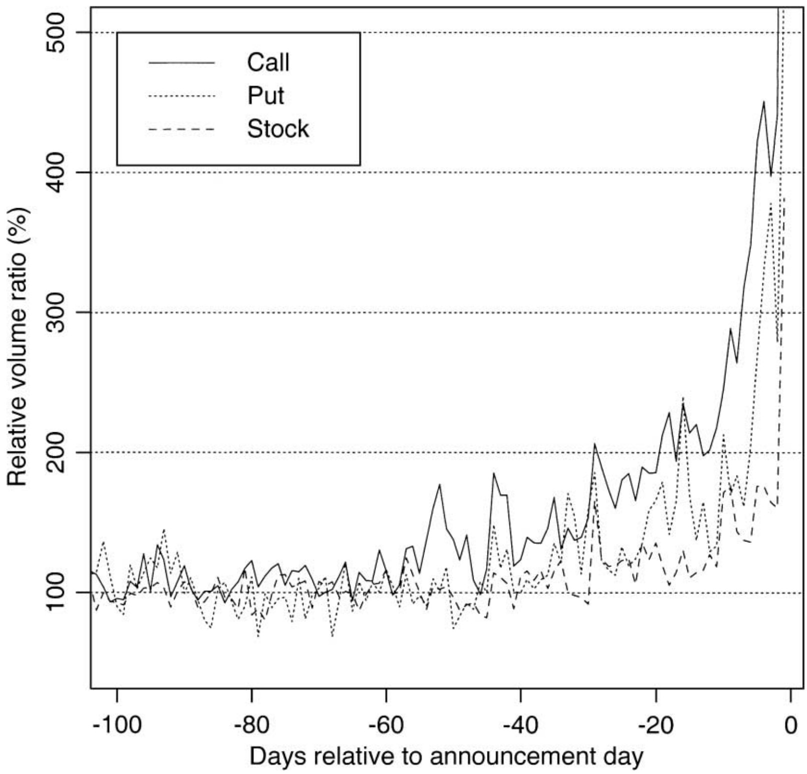

FIG. 1.—Daily ratio of call, put and stock volumes to their respective benchmark period volumes. The time-series of the cross-sectional average call, put and stock volumes is plotted from date −100 to −1, where date 0 is the announcement day. All volume measures are scaled by their respective security benchmark volumes. For each type of security and given date, the cross-sectional average of daily volume is divided by the average daily volume of that security in the benchmark [−200, −100] period.

the underlying stock. For example, on date −5 trading volume is 321% higher for calls, 168% higher for puts, and 76% higher for the stock than their respective benchmark levels. Figure 1 indicates that the call-option activity foreshadows the stock's activity prior to an announcement.

After the announcement, stock volume decreases dramatically but option volume remains high relative to its benchmark period level. For example, on date +5, the average call volume is 530% of its benchmark level, whereas the average put volume and stock volume are 627% and 209% of their respective benchmark-period levels. This increase in postannouncement option volume can be a result of informed traders locking in takeover premium, hedging, and "risk-arbitrage" activity.

Table 1 also reports the percentage volume imbalance for calls, puts, and stocks in the benchmark and preannouncement period. Both calls and stocks experience significant increases in imbalances in the preannouncement period. The average increase in call imbalance is 10.53%, while the average increase in stock imbalance is smaller, 6.41%. Put imbalance declines by 5.75%. Overall, there are more purchases of calls and stocks and more sales of puts in the preannouncement period.

Intuitively, if informed traders are present in the preannouncement period, the bid-ask spread should increase due to the presence of a more severe adverse-selection environment. Table 1 shows that calls (puts) experience a 5.2% (5.2%) increase in their dollar bid-ask spreads and a 8.6% (9.2%) increase in their prices. This translates into a 2.6% (3.0%) decline in the respective options' percentage bid-ask spreads. One explanation for this decline is that, while the adverse selection component of an option's bid-ask spread increases in the preannouncement period, it is offset by the fixed-cost component that falls with the increase in volume. Another explanation is that the adverse selection component of the spread increases but this change may be below the minimum tick size, such that the dollar bid-ask spread does not change significantly. A smaller increase in dollar bid-ask spread and a larger increase in option price may actually make the percentage spread lower. Therefore, even though the adverse selection cost is relatively severe ahead of takeover announcements, option contracts' bid-ask spreads may not be informative of pending events. Finally, the average cumulative abnormal stock return is 12.9% in the preannouncement period, which is similar to the 13.3% price run-up found by Schwert (1996) in a comprehensive sample of 1,814 target firms.

III. The Relative Informativeness of Option and Stock Markets

In this section, we use the differential information embedded in option and stock imbalances to examine our three hypotheses. Toward this goal, we present empirical results from a time-series regression analysis of the relation between option (and stock) imbalances and stock returns, relate this to takeover characteristics, perform a comparison of optioned and nonoptioned firms, and do a cross-sectional regression analysis of the takeover premium on run-ups in the stock and option volume.

A. Forecasting Returns with Imbalances during Normal and preannouncement periods

We first examine the relation between option (and stock) volume and the future stock excess returns in both the benchmark and preannouncement periods. The excess return is calculated using CRSP value-weighted portfolio return. We regress stock returns on lagged call and stock imbalances. Because signed (or directional) volume conveys more information on the direction of trading, we use buyer/seller-initiated volume.

Since the selling of puts is a bullish call on a stock, we also include buyer/seller-initiated put volume as an explanatory variable. Daily excess returns are correlated over time, we prewhiten returns so that we can focus on the unexpected component or the innovation in returns. We experimented with various specifications, and found the MA(1) model is sufficient to smooth excess return time series. We use the benchmark period data to estimate the parameters for each firm. These parameters are then used over the benchmark and the preannouncement periods to generate excess return residuals. To ensure that the variables are comparable across firms, all innovations are normalized by the standard deviation of that series during the firm's benchmark period. Observations from sample firms are then pooled together prior to estimation.

Table 2 presents estimates from the following time-series regression model:

$$r_t = \beta_0 + \beta_1 \text{ ShareOI}_{t-1} + \beta_2 \text{ CallOI}_{t-1} + \beta_3 \text{ PutOI}_{t-1} + \varepsilon_t, \quad (1)$$

where r is the standardized innovation in daily excess return, and ShareOI, CallOI, and PutOI are the standardized share, call option, and put option volume imbalances, respectively. For each type of security and each day, imbalances are calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period $[-200, -100]$, then this variable is standardized using its mean and standard deviation over the benchmark period.

Table 2 shows that in the benchmark-period-lagged share volume imbalances are significantly and positively related to next-day returns, but lagged call imbalances are not. This finding that, during normal periods, the stock market is more informative of a stock's future return than the options market is a direct rejection of our third hypothesis, H3. During the preannouncement period, however, the relation changes. Both stock and call imbalances are now significant predictors of next-day abnormal stock returns. The coefficient on call imbalances is relatively larger than that on stock imbalances; a 1 standard deviation shock to share-volume imbalances leads to a 0.024 standard deviation increase in next-day returns and a 1 standard deviation shock to call-volume imbalances leads to a 0.037 standard deviation increase in returns. Lagged put imbalances are not significant in predicting next-day stock returns. In sum, while stock-volume imbalances seem to contain information about the next-day's price movements during normal periods and prior to takeover announcements, call imbalances play a special additional information role about future price movements prior to takeover announcements.

One interesting question is how imbalances affect prices. Since trading activity is correlated over time, a large stock imbalance on one

TABLE 2 Time-Series Regressions of Next-Day Excess Returns

	Benchmark Period [−200, −100]		Preannouncement Period [−30, −1]	
	(1)	(2)	(1)	(2)
Constant	−.002	−.002	.103*	.085*
	(−.19)	(−.21)	(3.17)	(2.66)
ShareIO_{t-1}	.034*	.010	.024*	.011
	(2.67)	(.78)	(2.03)	(.93)
CallIO_{t-1}	.008	−.008	.037*	.022*
	(.73)	(−.75)	(2.96)	(2.55)
PutIO_{t-1}	.001	−.004	−.002	−.004
	(.12)	(−.34)	(−.56)	(−1.12)
ShareIO_{t}		.282*		.087*
		(23.94)		(11.56)
CallIO_{t}		−.084*		.087*
		(−6.95)		(4.80)
PutIO_{t}		.015		−.029
		(1.22)		(−1.59)
Adj. R^2	.001	.118	.022	.100

NOTE.—The regression results in the table are based on the following equation:

$$r_t = \beta_0 + \beta_1 \text{ ShareOI}_{t-1} + \beta_2 \text{ CallOI}_{t-1} + \beta_3 \text{ PutOI}_{t-1}$$
$$+\beta_4 \text{ ShareOI}_t + \beta_5 \text{ CallOI}_t + \beta_6 \text{ PutOI}_t + \varepsilon_t,$$

where r is the standardized innovation in daily excess return obtained from a MA(1) model. We estimate the MA(1) model by using observations from days [−200, −100], then use the resulting parameters to obtain the standardized innovations during [−200, −100] and [−30, −1]. ShareIO, CallIO, and PutIO are the standardized share, call, and put volume imbalances, respectively. For each type security and each day, the volume imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period [−200, −100]. For each firm, the imbalance is standardized using its mean and standard deviation in the benchmark period. The regression results are presented for the pooled sample in both the benchmark period [−200, −100] and the preannouncement period [−30, −1]. The sample is 78 takeover targets with options listed on the CBOE from 1986 through 1994. Regression coefficients and t-statistics (in parentheses; * indicates significance at the 5% level) are reported. In computing t-statistics, we use the standard errors that are White's (1980) heteroscedasticity consistent estimator.

day may mean that the next trading day also is associated with a large imbalance. If a buyer-initiated imbalance has a positive effect on returns, large buying pressure today may not necessarily mean that positive information will be released in the future but rather that investors will push up prices on the next trading day. Due to the linkages between the option and stock markets, a similar argument can be made that a large call imbalance today forecasts high option and stock imbalances on the next day that affects prices. To control for potential price pressure effects, we also include contemporaneous imbalances in our regressions. If lagged imbalances have forecasting power for next-day stock returns after controlling for contemporaneous imbalance effects, then it is strong evidence that imbalances are not simply forecasting future imbalances that move prices. It is important to note that controlling for contemporaneous imbalances is a stringent control for contemporaneous price pressure, because contemporaneous imbalances might also be associated with information. Specifically, we estimate the following regression model:

$$r_t = \beta_0 + \beta_1 \text{ ShareOI}_{t-1} + \beta_2 \text{ CallOI}_{t-1} + \beta_3 \text{ PutOI}_{t-1} + \beta_4 \text{ ShareOI}_t + \beta_5 \text{ CallOI}_t + \beta_6 \text{ PutOI}_t + \varepsilon_t, \tag{2}$$

As shown in table 2, the estimated coefficients on contemporaneous share imbalances in the benchmark and preannouncement periods are comparable, 0.282 versus 0.252. For contemporaneous call imbalances, the sign of the estimated coefficient changes from the benchmark to the preannouncement period (−0.084 versus 0.087). The positive coefficient on the contemporaneous share imbalances and negative coefficient on the contemporaneous call imbalances during the benchmark period are consistent with results reported in Easley et al. (1998) and Chan et al. (2002), where both studies examine the relation between return and signed volume for the 50 most active firms on the CBOE during a 3-month period.

In the benchmark period, for the specification in table 2 with contemporaneous imbalances in the regression, neither lagged stock, call, nor put imbalances are significant predictors of stock returns. In both, the benchmark and preannouncement period controlling for the contemporaneous relation removes the significance of lagged share imbalances found previously with the specification with only lagged imbalances. However, in the preannouncement period, after controlling for contemporaneous imbalances, lagged call imbalances are the only significant lagged predictor of stock returns. In sum, when the contemporaneous effects are not included in the regressions, we find support for our first hypothesis (H1), that option volume provides information prior to takeovers. Under the more stringent control for contemporaneous imbalances, our results also support the second hypothesis (H2), that option volume is more informative than stock volume prior to takeovers. Both specifications find that option volume is not informative during normal time periods—a direct rejection of H3.

We also perform similar analyses with volume instead of volume imbalances. While signed volume is more theoretically justified, since the nature of the trade is used, raw volume alone can be useful if there is noise in the trade classification algorithm or simply as an overall indicator of market interest. In the volume regressions, we find that only stock volume is informative of next-day stock returns during the benchmark period. During the preannouncement period, however, the picture is quite the opposite, as only lagged call volume is significant. These results indicate that option volume is more informative than stock volume prior to takeovers but not informative during normal times. To conserve space, these results are not reported.

B. Takeover Characteristics and the Imbalance and Return Relation

Takeovers that are ultimately successful and those with large stock price run-ups may be associated with more severe informed trading. If this is the case, then one would expect to see that preannouncement imbalances are more strongly related to future price movements in firms that are successful takeover targets and have large stock price increases. To investigate this possibility, we analyze regressions similar to those shown in table 2 except that we interact dummy variables for whether a takeover is successful and whether a target firm has large run-ups in the preannouncement period. The regression is estimated as follows:

$$\begin{aligned} r_t = {} & \beta_0 + \beta_1 \text{ ShareOI}_{t-1} + \beta_2 \text{ CallOI}_{t-1} + \beta_3 \text{ PutOI}_{t-1} + \beta_4 \text{ ShareOI}_t \\ & + \beta_5 \text{ CallOI}_t + \beta_6 \text{ PutOI}_t + \beta_7 \text{ I}^{\text{Successful}}\text{ShareOI}_{t-1} \\ & + \beta_8 \text{ I}^{\text{Successful}} \text{ CallOI}_{t-1} + \beta_9 \text{ I}^{\text{Successful}}\text{PutOI}_{t-1} \\ & + \beta_{10} \text{ I}^{\text{LargeRunup}} \text{ ShareOI}_{t-1} + \beta_{11} \text{ I}^{\text{LargeRunup}}\text{CallOI}_{t-1} \\ & + \beta_{12} \text{ I}^{\text{LargeRunup}}\text{PutOI}_{t-1}\varepsilon_t, \end{aligned} \tag{3}$$

where $I^{\text{Successful}}$ and $I^{\text{LargeRunup}}$ are dummy variables for whether the deal was complete in the 2-year period after the announcement date and whether the run-up during $[-30, -1]$ is in the ex post upper 50 percentile.[3]

The results displayed in panel A of table 3 show that, in the first specification (with no contemporaneous regressors), the dummy variables interactions are not important in the benchmark period (as should be expected), however, they play an important role in the preannouncement period. Lagged share imbalances are significant overall, but the insignificant coefficients on the successful or large run-up dummy variable interacted with lagged share imbalances indicate that characteristics of the takeover do not affect the stock imbalance-return relation. On the other hand, the effect of call imbalances are concentrated in firms that eventually have a successful takeover. The large run-up dummy variable plays no important role with call imbalances, and put imbalances are not significantly related to future stock returns. Controlling for the contemporaneous imbalances again strengthens the relative influence of the call volume imbalances. After including the contemporaneous imbalances in the regression, neither the share-imbalances variable nor share imbalances that interacted with either dummy variable are statistically significant. However, call imbalances are again related to future returns for takeover targets that are ultimately successful. These results indicate that the activity in the call market bears information about the likelihood

3. We also measure the run-up from day 30 to +1 and find similar results.

TABLE 3 Time-Series Regressions of Excess Returns Using Firm Characteristics

	Panel A. Using First Bid Date				Panel B. Using Rumor Date			
	[−200, −100]		[−30, −1]		[−200, −100]		[−30, −1]	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Constant	−.002	−.002	.100*	.081*	−.002	−.002	.103*	.062*
	(−.19)	(−.21)	(3.06)	(2.47)	(−.22)	(−.21)	(3.23)	(2.00)
ShareOI_{t-1}	.040*	.013	.033*	.015	.031*	.010	.023*	.024
	(2.00)	(1.07)	(2.38)	(.96)	(2.02)	(1.10)	(1.97)	(.61)
CallOI_{t-1}	.007	−.015	.014	.010	.002	−.21	.016	.005
	(.34)	(−.75)	(1.06)	(1.03)	(.10)	(−1.05)	(1.00)	(.20)
PutOI_{t-1}	−.006	−.003	.009	.011	−.002	−.001	.014	.014
	(−.31)	−.17	(.80)	(.75)	(−.11)	(−.05)	(1.02)	(.96)
ShareOI_{t}		.282*		.252*		.274*		.272*
		(23.93)		(11.32)		(22.83)		(11.62)
CallOI_{t}		−.084*		.093*		−.084*		.103*
		(−6.95)		(5.06)		(−6.82)		(5.50)
PutOI_{t}		.015		−.033		.016		−.038
		(1.25)		(−1.72)		(1.29)		(−2.00)
$I^{\text{Successful}}\text{ShareOI}_{t-1}$	.004	.003	−.020	−.012	.014	.013	−.21	−.033
	(.16)	(.14)	(−.52)	(−.35)	(.57)	(.53)	(−.51)	(−.79)
$I^{\text{Successful}}\text{CallOI}_{t-1}$	.006	.018	.050*	.056*	.013	.022	.063*	.075*
	.28	(.78)	(2.61)	(2.70)	(.52)	(.93)	(2.81)	(2.92)
$I^{\text{Successful}}\text{PutOI}_{t-1}$	.023	.022	−.012	−.010	.023	.020	−.018	−.015
	(1.08)	(.95)	(−.54)	(−.73)	(.88)	(.77)	(−1.12)	(−1.01)

TABLE 3 ***(Continued)***

	Panel A. Using First Bid Date				Panel B. Using Rumor Date			
	[−200, −100]		[−30, −1]		[−200, −100]		[−30, −1]	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
$I^{\text{LargeRunup}}\text{ShareOI}_{t-1}$	−.014	−.004	.024	.010	−.012	−.010	.031	.015
	(−.57)	(−.18)	(.64)	(.30)	(−.45)	(−.36)	(.70)	(.37)
$I^{\text{LargeRunup}}\text{CallOI}_{t-1}$	−.003	−.005	−.001	−.015	−.001	−.002	−.012	−.025
	(−.14)	(−.23)	(−.02)	(−1.00)	(−.07)	(−.07)	(−.40)	(−1.82)
$I^{\text{LargeRunup}}\text{PutOI}_{t-1}$	−.009	−.023	−.010	−.013	−.008	−.020	−.016	−.022
	(−.37)	(−.95)	(−.81)	(−.98)	(−.32)	(−.90)	(−1.12)	(−1.60)
Adj. R^2	.001	.119	.023	.103	.001	.114	.033	.110

NOTE.—The regression results in the table are based on the following equation:

$$\begin{aligned} r_t = {} & \beta_0 + \beta_1\text{ShareOI}_{t-1} + \beta_2\text{CallOI}_{t-1} + \beta_3\text{PutOI}_{t-1} + \beta_4\text{ShareOI}_t + \beta_5\text{CallOI}_t + \beta_6\text{PutOI}_t \\ & + \beta_7\text{I}^{\text{Successful}}\text{ShareOI}_{t-1} + \beta_8\text{I}^{\text{Successful}}\text{CallOI}_{t-1} + \beta_9\text{I}^{\text{Successful}}\text{PutOI}_{t-1} \\ & + \beta_{10}\text{I}^{\text{LargeRunup}}\text{ShareOI}_{t-1} + \beta_{11}\text{I}^{\text{LargeRunup}}\text{CallOI}_{t-1} + \beta_{12}\text{I}^{\text{LargeRunup}}\text{PutOI}_{t-1} + \varepsilon_t, \end{aligned}$$

where r is the standardized innovation in daily excess return obtained from a MA(1) model. We estimate the MA(1) model by using observations from [−200, −100], then using the resulting parameters to obtain the standardized innovations during [−200, −100] and [−30, −1].ShareOI, CallOI, and PutOI are the standardized share, call, and put volume imbalances, respectively. For each type security and each day, the volume imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period [−200, −100]. For each firm, the imbalance is standardized using its mean and standard deviation in the benchmark period. $I^{\text{Successful}}$ and $I^{\text{LargeRunup}}$ are dummy variables for whether the deal was complete in the 2-year period after the announcement date and whether the run-up from day −30 to day −1 was in the upper 50 percentile. The regression results are presented for the pooled sample in both the benchmark period [−200, −100] and the preannouncement period [−30, −1]. The sample is 78 takeover targets with options listed on the CBOE from 1986 through 1994. Regression coefficients and t-statistics (in parentheses; * indicates significance at the 5% level) are reported. In computing t-statistics, we use the standard errors that are White's (1980) heteroscedasticity consistent estimator. In panel A, we use the first official bid date and in panel B the rumor date (when applicable) as the announcement date.

of the success of the future deal. Again, these results support the hypothesis that more information is revealed in calls than in stock volume prior to takeover announcements (H2).

So far, the announcement day used in the analysis is the first day an official bid is received. Prior to a takeover announcement, one can often trace rumors related to the future event. Thus, an alternative definition of the announcement day can be the first rumor day. To check whether our results are sensitive to alternative definitions of announcement day, when applicable, we replace the first bid day by the first rumor day if a publicly traceable rumor can be identified within the 6 months prior to announcement.[4] We then rerun the regressions and report the results in panel B of table 3. The results are similar to those reported in panel A. Again, when the contemporaneous imbalances are included in the regression, call imbalances for successful takeovers are the only lagged variable that is significant.

Tables 2 and 3 both find that, absent significant informational events, stock market activities tend to be more predictive of next-day price action than activities on the options market. But, during times of potentially large informational asymmetry, the derivatives market plays a more significant role than the underlying stock market. These results are consistent with hypotheses H1 and H2. Therefore, when information-based trading is prevalent, the options market may offer stronger incentives and more efficient trading instruments, thus attracting more informed traders.

C. *Pairwise Comparison*

In this section, we expand our analysis by performing a pairwise comparison between takeover targets with and without options traded. Our objective is to test for difference in the imbalance-return relation between option firms and nonoption firms in the benchmark and preannouncement periods. We examine whether price discovery for nonoptioned firms occurs in the stock market during both normal and informational periods, and if there is additional price discovery in the options market beyond that in the stock market for firms with options.

We use three matching variables, similar to those of Huang and Stoll (1996) and Cao, Choe, and Hatheway (1997), to obtain a matched sample. The matching variables are the firm size, share price, and share volume. Specifically, for each target firm i with options traded in our sample, we construct our matching nonoption sample by identifying all takeover targets that have no options traded on any exchange and have announcement dates within 1 year [$t - 1$ year, $t + 1$ year] of the announcement date (t) for firm i. For a potential matching firm

4. We found a publicly traceable rumor for 34% of our sample firms.

j, we use the following three matching variables to construct a score statistic:

$$\text{score}_{i,j} = \left(\frac{\text{price}_i - \text{price}_j}{\frac{\text{price}_i + \text{price}_j}{2}} \right)^2 + \left(\frac{\text{share volume}_i - \text{share volume}_j}{\frac{\text{share volume}_i + \text{share volume}_j}{2}} \right)^2 + \left(\frac{\text{size}_i - \text{size}_j}{\frac{\text{size}_i + \text{size}_j}{2}} \right)^2, \tag{4}$$

where price, share volume, and size are averages of daily stock price, share volume, and market capitalization in the benchmark period [−200, −100]. We select the firm with the lowest score from potential matching firms as the firm matched with firm i.

On average, daily share prices are \$36.40 and \$31.63, respectively, for option and nonoption firms. Option firms have a larger market capitalization (\$2.02 billion) in comparison to nonoption firms (\$1.70 billion). In addition, the daily average volume of option firms is slightly larger (272,000 shares versus 236,000 shares). Overall, the option and nonoption samples are reasonably well matched.

Using the procedures described in Section III.A, we combine observations from the option and control samples to estimate the following time-series regression model:

$$\begin{aligned} r_t = {} & \beta_0 + \beta_1\, I^{\text{Op}}\, \text{ShareOI}_{t-1} + \beta_2\, I^{\text{Nonop}}\, \text{ShareOI}_{t-1} + \beta_3\, I^{\text{Op}}\, \text{CallOI}_{t-1} \\ & + \beta_4\, I^{\text{Op}}\, \text{PutOI}_{t-1} + \gamma_1\, I^{\text{Preann}}\, I^{\text{Op}}\, \text{ShareOI}_{t-1} \\ & + \gamma_2\, I^{\text{Preann}}\, I^{\text{Nonop}}\, \text{ShareOI}_{t-1} + \gamma_3\, I^{\text{Preann}}\, I^{\text{Op}}\, \text{CallOI}_{t-1} \\ & + \gamma_4\, I^{\text{Preann}}\, I^{\text{Op}}\, \text{PutOI}_{t-1} + \varepsilon_t, \end{aligned} \tag{5}$$

where I^{Op} (or I^{Nonop}) is an indicator variable for whether the observation is from a target firm with (or without) options traded, and I^{Preann} is a dummy variable for whether the observation is from the preannouncement period [−30, −1] or the benchmark period [−200, −100]. It is important to note that variables that interacted with the preannouncement period dummy represent the marginal effect of each variable over and above that in the benchmark period.

In table 4, we examine the specification without the contemporaneous imbalance, as shown in the preceding equation. We test for whether there is a difference in the share imbalance coefficient between firms with and without options. Our primary test statistics are the difference between β_1 and β_2 and that between γ_1 and γ_2. In the benchmark period, the lagged share imbalances are significant for firms both with and without traded options. Specifically, a 1 standard deviation shock to stock imbalances is associated with a 0.034 (0.027) standard deviation

TABLE 4 **Test for the Difference in the Volume Imbalance-Return Relationship between Takeover Target Firms with and without Options**

	With Options		Without Options	
	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Constant	.023*	(2.81)	.020*	(2.38)
$I^{\text{Op}}\text{ShareOI}_{t-1}$	.034*	(2.34)	.010	(.68)
$I^{\text{Nonop}}\text{ShareOI}_{t-1}$	.027*	(2.07)	−.008	(−.60)
$I^{\text{Op}}\text{CallOI}_{t-1}$	.008	(1.01)	−.009	(−.66)
$I^{\text{Op}}\text{PutOI}_{t-1}$	.001	(.10)	−.004	(−.30)
$I^{\text{Preann}}I^{\text{Op}}\text{ShareOI}_{t-1}$	−.010	(−1.023)	.001	(.03)
$I^{\text{Preann}}I^{\text{Nonop}}\text{ShareOI}_{t-1}$	.019	(1.81)	.041*	(2.27)
$I^{\text{Preann}}I^{\text{Op}}\text{CallOI}_{t-1}$	.030*	(3.03)	.031*	(2.12)
$I^{\text{Preann}}I^{\text{Op}}\text{PutOI}_{t-1}$	−.003	(−.41)	.000	(.02)
$I^{\text{Op}}\text{ShareOI}_{t}{}^{*}$			.282*	(20.80)
$I^{\text{Nonop}}\text{ShareOI}_{t}$			.340*	(24.80)
$I^{\text{Op}}\text{CallOI}_{t}$			−.084*	(−6.04)
$I^{\text{Op}}\text{PutOI}_{t}$			.015	(1.05)
$I^{\text{Preann}}I^{\text{Op}}\text{ShareOI}_{t}$			−.030	(−1.66)
$I^{\text{Preann}}I^{\text{Nonop}}\text{ShareOI}_{t}$			−.082*	(−3.72)
$I^{\text{Preann}}I^{\text{Op}}\text{CallOI}_{t}$			.171*	(8.63)
$I^{\text{Preann}}I^{\text{Op}}\text{PutOI}_{t}$			−.044*	(−2.32)
Adj. R^2	.012		.109	

NOTE.—The regression results in the table are based on the following equation:

$$\begin{aligned} r_t = {} & \beta_0 + \beta_1 I^{\text{Op}}\text{ShareOI}_{t-1} + \beta_2 I^{\text{Nonop}}\text{ShareOI}_{t-1} + \beta_3 I^{\text{Op}}\text{CallOI}_{t-1} + \beta_4 I^{\text{Op}}\text{PutOI}_{t-1} \\ & + \gamma_1 I^{\text{Preann}} I^{\text{Op}}\text{ShareOI}_{t-1} + \gamma_2 I^{\text{Preann}} I^{\text{Nonop}}\text{ShareOI}_{t-1} \\ & + \gamma_3 I^{\text{Preann}} I^{\text{Op}}\text{CallOI}_{t-1} + \gamma_4 I^{\text{Preann}} I^{\text{Op}}\text{PutOI}_{t-1} \\ & + \beta_{11} I^{\text{Op}}\text{ShareOI}_t + \beta_{12} I^{\text{Nonop}}\text{ShareOI}_t + \beta_{13} I^{\text{Op}}\text{CallOI}_t + \beta_{14} I^{\text{Op}}\text{PutOI}_t \\ & + \gamma_{11} I^{\text{Preann}} I^{\text{Op}}\text{ShareOI}_t + \gamma_{12} I^{\text{Preann}} I^{\text{Nonop}}\text{ShareOI}_t \\ & + \gamma_{13} I^{\text{Preann}} I^{\text{Op}}\text{CallOI}_t + \gamma_{14} I^{\text{Preann}} I^{\text{Op}}\text{PutOI}_t + \varepsilon_t, \end{aligned}$$

where r is the standardized innovation in daily excess return obtained from a MA(1) model. We estimate the MA(1) model by using observations from [−200, −100], then using the resulting parameters to obtain the standardized innovations during [−200, −100] and [−30, −1]. ShareOI, CallOI, and PutOI are the standardized share, call, and put volume imbalances, respectively. For each type security and each day, the volume imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period [−200, −100]. For each firm, the imbalance is standardized using its mean and standard deviation in the benchmark period. I^{Op} (or I^{Nonop}) is a dummy variable for whether the observation is from a target firm with (or without) listed options, and I^{Preann} is a dummy variable for whether the observation is from the preannouncement period [−30, −1]. The regression results are presented for the pooled sample in both the benchmark and the preannouncement periods. The sample is 78 takeover targets with options listed on the CBOE from 1986 through 1994 and another 78 matched target firms without listed options. Regression coefficients and *t*-statistics (in parentheses; * indicates significance at the 5% level) are reported. In computing *t*-statistics, we use the standard errors that are White's (1980) heteroscedasticity consistent estimator.

increase in next-day returns over the benchmark period for optioned (nonoptioned) firms. The difference in the share imbalance coefficient between the optioned firms and nonoptioned firms (i.e., $\beta_1 - \beta_2$) is insignificant. Further, the lagged call and put imbalances are not significant. Thus, in the benchmark period, the stock market activity is more informative about next-day returns, whether a stock has options traded on it or not.

During the preannouncement period, the lagged stock imbalance remains significant for target firms with options traded; however, the stock imbalance is less strongly related to future returns (γ_1 = −0.01). In contrast, nonoptioned firms experience an increase in the sensitivity between returns and the lagged share imbalance (γ_2 = 0.019) that is significant at the 10% level. The difference between γ_1 and γ_2 is also significant at the 10% level. Thus, for nonoptioned stocks, a 1 standard deviation increase in stock imbalances has a stronger relation to next-day returns in the preannouncement period, while there is no increase in this relation for optioned stocks.

These findings bring up the question of how information revelation is different between the call market and the stock market for optioned and nonoptioned firms. For firms with options, we first examine whether the benchmark stock imbalance sensitivity is comparable to the preannouncement combined stock and option sensitivity (i.e., H_0: $\beta_1 = (\beta_1 + \gamma_1) + (\beta_3 + \gamma_3)$, versus H_a: $\beta_1 < (\beta_1 + \gamma_1) + (\beta_3 + \gamma_3)$). At the 10% level, we reject the null hypothesis that stock imbalance sensitivities in the benchmark period are the same as the combined stock and call imbalance sensitivities in the preannouncement period. This additional sensitivity is due mostly to the incremental call sensitivity (γ_3 = 0.03 with *t*-statistic = 3.03). Thus, there is additional price discovery in the options market prior to pending events.

Next, we examine the relation between preannouncement stock imbalances and returns for optioned and nonoptioned stocks. If information-based traders prefer the options market during periods of large information asymmetry and substitute their trading from stocks to options, then we would expect to see that preannouncement stock imbalance sensitivities for optioned firms are lower than those for nonoptioned firms (i.e., H_0: $\beta_1 + \gamma_1 = \beta_2 + \gamma_2$ versus H_a: $\beta_1 + \gamma_1 < \beta_2 + \gamma_2$). The null hypothesis is rejected at the 6% confidence level.

Finally, we examine whether preannouncement stock volume sensitivities for nonoptioned stocks are comparable to preannouncement combined stock and option sensitivities for optioned stocks (i.e., H_0: $\beta_2 + \gamma_2 = (\beta_1 + \gamma_1) + (\beta_3 + \gamma_3)$). We find that there is little difference between these sensitivities. These results suggest that, for firms with options, the option imbalances appear to substitute, at least partly, for stock imbalances in providing information about next-day price moves prior to takeover announcements.

To control for the persistence in imbalances, we include the contemporaneous stock, call, and put imbalances in the above specification. The results reported in table 4 are similar to those without the contemporaneous variables, except that lagged stock imbalances are no longer significant for optioned firms but significant only in the preannouncement period for nonoptioned firms. Regardless of whether we control for the contemporaneous imbalances, lagged call imbalances are not significant in the benchmark period but significant in the preannouncement period. The increase in lagged share imbalance sensitivity from the benchmark period to preannouncement period is significant for nonoptioned firms only.

Collectively, this matched-sample exercise indicates that, when both the stock and options markets are available trading venues, option imbalance displaces information that might otherwise be shown in stock imbalances during periods with takeover-related information (H2). However, during a normal period, without pending informational events, the stock market may still be the primary place where price discovery occurs (a rejection of H3).

D. Predicting Event-Day Returns

Our analysis so far has focused on the differential ability of imbalance variables to predict next-day abnormal returns, during normal versus preannouncement periods. Our ultimate goal is to see which market offers more significant clues about pending informational events. In this section, we investigate the relation between preannouncement volume run-up and announcement-day abnormal returns. We conduct a cross-sectional regression, where the dependent variable is the announcement 2-day cumulative abnormal returns and the explanatory variables are preannouncement stock-price run-up and the change in the stock and option imbalances. The announcement-return regression model is

$$\begin{aligned}\mathrm{CAR}[0,1]_i = {} & \beta_0 + \beta_1 \mathrm{CAR}[-30,-1]_i + \beta_2\ \Delta\mathrm{ShareOI}_i \\ & + \beta_3\ \Delta\mathrm{CallOI}_i + \beta_4\ \Delta\mathrm{PutOI}_i + \beta_5\ I_i^{\mathrm{Successful}} \\ & + \beta_6\ I_i^{\mathrm{Takeover}} + \beta_7\ I_i^{\mathrm{Rumor}} + \beta_8\ I_i^{\mathrm{Hostile}} + \beta_9\ I_i^{\mathrm{Cash}} + \varepsilon_i, \quad (6)\end{aligned}$$

where CAR[0, 1] is the 2-day cumulative abnormal return from day 0 to day 1, CAR[−30, −1] is the preannouncement price run-up. The ΔShareOI, ΔCallOI, and ΔPutOI are changes in share, call, and put volume imbalances, respectively, from the benchmark period to the preannouncement period. The $I^{\mathrm{Successful}}$, I^{Takeover}, I^{Rumor}, I^{Hostile}, and I^{Cash} are dummy variables for whether the deal was complete in the 2-year period after the announcement date, whether the deal is a takeover or merger, whether a publicly traceable rumor occurred within the 6 months prior to the announcement date, whether the takeover was friendly or hostile, and whether or not the primary method of payment was cash.

Table 5 reports the regression results. We consider three alternative specifications. The first specification includes stock price run-up, change in stock volume imbalances, and change in call and put volume imbalances. The coefficient on the change in call imbalances is positive and significant (t-statistic = 2.77), whereas the preannouncement stock-imbalance changes are positively associated with announcement

TABLE 5 Cross-Sectional Regressions of Announcement-Day Returns

	Dependent Variable: CAR [0, 1]		
	(1)	(2)	(3)
Constant	.13*	.11*	.07*
	(4.87)	(2.79)	(2.00)
CAR[−30, −1]	−.06	−.05	−.06
	(−.42)	(−.37)	(−.41)
ΔShareOI	.21	.12	.11
	(1.14)	(.62)	(.57)
ΔCallOI	.19*	.21*	.26*
	(2.77)	(3.08)	(3.44)
ΔPutOI	−.07	−.09*	−.11*
	(−1.94)	(−2.48)	(−2.80)
$I^{\text{Successful}}$		.08	.09
		(1.61)	(1.78)
I^{Takeover}		.03	.02
		(1.20)	(.89)
I^{Rumor}			.01
			(.06)
i^{Hostile}			.10
			(1.57)
I^{Cash}			.08
			(.74)
Adj. R^2	.092	.123	.123

NOTE.—The regression results in the table are based on the following equation:

$$\text{CAR}[0,1]_i = \beta_0 + \beta_1\ \text{CAR}[-30,-1]_i + \beta_2\ \Delta\text{ShareOI}_i + \beta_3\ \Delta\text{CallOI}_i + \beta_4\ \Delta\text{PutOI}_i + \beta_5\ I_i^{\text{Successful}} + \beta_6\ I_i^{\text{Takeover}} + \beta_7\ I_i^{\text{Rumor}} + \beta_8\ I_i^{\text{Hostile}} + \beta_9\ I_i^{\text{Cash}} + \varepsilon_i, \quad (6)$$

where CAR[0, 1] is the 2-day cumulative abnormal return from day 0 to day 1 and CAR[−30, −1] the cumulative abnormal return from day −30 to day −1. Day 0 is the announcement day. ΔShareOI, ΔCallOI, and ΔPutOI are changes in share, call, and put volume imbalances, respectively, from the benchmark period to the preannouncement period. For each type security and each day, the imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average volume in the benchmark period [−200, −100]. period. $I^{\text{Successful}}, i^{\text{Takeover}}, i^{\text{Rumor}}, I^{\text{Hostile}}$, and I^{Cash} are dummy variables for whether the deal was complete in the 2-year period after the announcement date, whether the deal is a takeover or merger, whether a publicly traceable rumor occurred within the 6 months prior to the announcement date, whether the takeover was friendly or hostile, and whether or not the primary method of payment was cash. The abnormal return is the difference between the raw return and the CRSP value-weighted portfolio return. Regression coefficients and *t*-statistics (in parentheses; * indicates significance at the 5% level) are reported. In computing *t*-statistics, we use the standard errors that are White's (1980) heteroscedasticity consistent estimator.

returns but insignificant (*t*-statistic = 1.14). In the second specification, we add dummy variables for whether the deal is ultimately successful and whether the deal is a takeover or merger. In this case, large increases (decreases) in call (put) imbalances still precede large takeover-announcement returns. Finally, including additional control variables for whether a publicly traceable rumor occurred within the 6 months prior to the announcement date, whether the takeover is friendly or hostile, and whether or not the primary method of payment was cash does not alter the coefficient and significance of the change in call and put imbalances. In unreported results, we estimate similar regressions with stock and call volume changes instead of imbalance changes and similarly find that call volume but not stock volume foreshadows future announcement-day returns.

These results indicate that the "surprise" component in a takeover announcement is not related to preannouncement stock activities but to preannouncement call activities. A possible explanation is that information contained in the preannouncement stock trading activities is already reflected in the preannouncement stock price. At the time of announcement, a major part of the exact takeover premium is a true "surprise" to stock market participants. On the other hand, only part of the information embedded in the preannouncement option trading may be reflected in the preannouncement stock price. Consequently, the preannouncement call-imbalance changes still foreshadow pending events and are a significant predictor of future takeover-premium "surprises." Thus, the results of table 5 support hypothesis H2 that the option market contains more information about future events than the stock market.

In summary, the time-series regression results suggests that call but not stock imbalances are associated with higher stock returns on the next trading day prior to a takeover announcement (H1 and H2). This relation holds only for the immediate period prior to takeovers and not periods of normal trading activity (a rejection of H3). Consistent with H2, the cross-sectional regression analysis suggests that option imbalance (and volume) changes contain additional information about the announcement-day returns as well.

IV. Trading Across Option Moneyness and Maturity and Post-Announcement Activity

We next turn to examining (1) how preannouncement trading activity differs across option contracts and (2) if postannouncement trading is informative of future deal outcomes. For preannouncement trading, one might expect to infer important information about the likelihood of a pending merger deal by investigating which strike prices and maturities receive concentrated trading. The rationale for making inferences from option contracts has to do with the incentives faced by an informed trader. As modeled by Easley et al. (1998), the informed trader chooses between the stock and options markets so as to maximize expected returns and minimize trading costs. Choosing out-of-the-money calls has the effect of increasing leverage. However, OTM options generally are less liquid (with higher relative bid-ask spreads) than ATM and ITM options. For instance, in our sample, OTM options have an average bid-ask spread of 26.6%, compared to a percentage bid-ask spread of 9.4% for ITM calls. But, in the presence of superior information, the leverage effect may dominate the liquidity consideration. Similarly, to avoid a high option premium, an informed trader may prefer short-term over long-term contracts, as the former offer higher leverage and generally are more liquid. Yet, the options' remaining lifetime must be long enough to cover the likely announcement date. Although we cannot identify the true strategy behind every trade, we can infer information from the observed activities across option moneyness and maturity. In the first part of this section, we examine call and put volume for option contracts in each moneyness-maturity category as well as buyer- and seller-initiated trading activity in these contracts.

In the second part of this section, we examine postannouncement takeover activity for successful and unsuccessful takeover targets. Most of the price run-up and, hence, profitability from buying options on a takeover target come prior to the announcement and on the announcement date. However, even after an announcement, a tender offer target firm usually appreciates to a price close to but slightly under the future tender offer price. The small appreciation in price after the announcement to the target firm likely will be earned if the takeover deal or merger is successfully completed. Yet, an investor holding an unsuccessful takeover target likely will earn negative returns. Investors called *risk arbitrageurs* speculate on the probability of a future success or failure of the takeover or merger. While there is some information asymmetry postannouncement, the asymmetry is generally much less than that in the postannouncement period and the potential profits for informed trading is less. It therefore is an empirical question of whether postannouncement option activity is informative of proposed takeover outcomes.

Barone-Adesi, Brown, and Harlow (1994) find that risk arbitrageurs seem to set option prices in such a way that they are indicative of the future success and timing of a proposed acquisition. They find that information embedded in implied volatility foreshadows the outcome and timing of a proposed merger or acquisition. We examine the aggregate information content in postannouncement activity by focusing on the buyer/seller-initiated trading volume and the success of a proposed merger. If the postannouncement call (put) activity is dominated by informed traders, then the trading activity should be predominately buy (sell) related in takeover deals that are ultimately successful. Conversely, if potential profit is not substantial and trading activity is predominately speculative in the postannouncement period, then no clear patterns may be apparent.

A. Differences in Trading Volume

In table 6, we examine preannouncement call and put volume changes across moneyness and maturity categories. In table 7, we examine buyer- and seller-initiated volume for each option category. Note that relatively more calls become in the money during the preannouncement period, as stock prices tend to increase significantly (see table 1). To control for changes in the number of unique option contracts available in a given

TABLE 6 Call and Put Volume across Moneyness-Maturity Categories

	Days to Expiration = 60 Days			Days to Expiration > 60 days		
Moneyness	[−200, −100]	[−30, −1]	% Change	[−200, −100]	[−30, −1]	% Change
Call Options						
OTM	40	104	166*†	26	38	46*†
ATM	62	144	132*,+	25	39	56*†
ITM	22	50	127*,+	11	15	36*†
Put Options						
OTM	16	34	112*†	11	11	0
ATM	23	38	65*†	9	9	0
ITM	9	12	33	5	5	0

NOTE.—For each moneyness-maturity category, the cross-sectional averages of daily volume are reported for calls and puts in the benchmark period [−200, −100] and the preannouncement period [−30, −1]. OTM, ATM, and ITM denote out-of-the money, at-the-money, and in-the-money options, respectively. The null hypothesis of no difference in means (or medians) between the benchmark and preannouncement period volumes is tested by using the *t*-test (or the nonparametric Wilcoxon test), where * and † indicate significance at the 5% level using the *t*-test and nonparametric test. To facilitate comparison across moneyness-maturity categories, we define call (or put) volume to be the number of contracts traded divided by the total number of unique contracts available in a given moneyness-maturity category.

moneyness category, for tables 6 and 7, we define option volume to be the number of contracts traded divided by the total number of unique contracts available in the same option moneyness-maturity category.

Interestingly, table 6 shows that the most increase in trading activity occurs in contracts with less than 2 months to expiration. The increase in short-term OTM, ATM, and ITM call volume is 166%, 132%, and 127%, respectively, while the corresponding increases in long-term call volume are 46%, 56%, and 36%. This suggests that the majority of traders are relatively confident that the announcement date will occur within 2 months. Among short-term calls, the OTM options experience the greatest percentage increase in volume. Short-term OTM calls are usually considered to be the most speculative and most risky financial instruments: they not only make it highly probable to lose 100% of the investment, but the potential loss can take place quickly. Given this property about short-term OTM calls, when they suddenly become the focus of option trading activities, the change should be highly indicative that some informational event is pending. At least within our takeover sample, this indeed seems to be the case: highly unusual trading in short-term OTM calls precedes takeover announcements.

All the volume increases in puts come from short-term activity, as puts with greater than 60 days to maturity experience no increase in volume activity. Among short-term puts, the out-of-the-money contracts are associated with the largest percentage increase in volume (112% increase). It is important to note, though, that in the preannouncement period, the average of 34 option contracts for short-term OTM puts is much less than the 104 OTM calls traded over this period.

TABLE 7 Buyer- and Seller-Initiated Option Volume across Moneyness-Maturity Categories

		Buyer Initiated			Seller Initiated			
Days to Expiration		[−200, −100]	[−30, −1]	% Change	[−200, −100]	[−30, −1]	% Change	Difference in % Change Between Buy and Sell
A. Call Options								
$T \leq 60$ days	OTM	15	45	200	16	39	143	$57^{*\dagger}$
	ATM	23	60	160	28	64	128	$32^{*\dagger}$
	ITM	8	19	137	10	24	140	−3
$T > 60$ days	OTM	9	15	67	10	16	60	7
	ATM	9	15	67	11	18	64	3
	ITM	4	6	50	4	6	50	0
B. Put Options								
$T \leq 60$ days	OTM	7	16	128	7	14	100	28
	ATM	9	15	67	10	18	80	$-13^{\dagger}$
	ITM	4	5	25	4	6	44	$-19^{\dagger}$
$T > 60$ days	OTM	4	4	0	4	5	25	$-25^{\dagger}$
	ATM	3	3	0	5	5	0	0
	ITM	2	2	0	2	2	0	0

NOTE.—The cross-sectional averages across firms of daily buyer- and seller-initiated call and put volume are reported for each moneyness-maturity categories. The average daily volume is reported both in the benchmark period [−200, −100] and the preannouncement period [−30, −1]. OTM, ATM, and ITM denote out-of the money, at-the-money, and in-the-money options, respectively. A trade is classified as buyer-initiated or seller-initiated as follows. Trades occurring in the lower half of the spread, at the bid or below, are classified as sells. Trades occurring in the upper half of the spread, at the ask or above, are classified as buys. Trades occurring at the midpoint of the spread are further classified as a buy (or sell) if the current price is higher (or lower) than the price of previous trade. Trades that are still unclassifiable are identified as cross trades and excluded. The null hypothesis of no difference in percentage change between buyer- and seller-initiated volume is tested by using the *t*-test (or the nonparametric Wilcoxon test), where * and † indicate significance at the 5% using the *t*-test and nonparametric test. To facilitate comparison across moneyness-maturity categories, we define call (or put) volume to be the number of contracts traded divided by the total number of unique contracts available in a given moneyness-maturity category.

While volume is informative, without knowing whether an investor is buying or selling an option, it is impossible to know the exact nature of the trade. For instance, while puts are generally bearish, an investor might sell a put if she expected a stock to experience a price increase. Thus, in table 7, we present the cross-sectional averages of buyer-initiated and seller-initiated call and put volume for various moneyness-maturity combinations.

The increase in trading activity differs across moneyness-maturity categories. For short-term OTM calls, buyer-initiated volume increases by 200%, whereas seller-initiated volume increases by 143%. This difference in volume change is significant at the 5% level, based on both the *t*-test and the nonparametric test. For short-term ATM calls, we see the same results; buyer-initiated call volume increases more than sell-initiated volume. Similarly, the increase in buyer-initiated volume is larger than that in seller-initiated volume for both long-term OTM and ATM calls. However, the magnitude of these volume-changes for long-term calls is far less. For puts, we see that buyer-initiated increases dominate in the short-term OTM contracts but seller-initiated increases dominate in short-term ATM and ITM contracts. In general, the increase in put trading is seller initiated.

In summary, prior to takeovers, activity pickup in the options market more often is 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 and intensified trading activity is attributed to differences in opinion, one would expect the buyer- and seller-initiated volume to change by similar amounts. The bullish bias in increased trading activity prior to takeovers in the most profitable contracts again is consistent with the hypothesis that option volume contains information about subsequent stock price changes.

B. Postannouncement Option Activity

Our previous analysis focuses on preannouncement activity, because this is where information asymmetry is most severe. However, an important question unanswered is whether postannouncement trading is informative of future takeover deal outcomes. Now, we investigate whether buy trading dominates calls of successful takeover targets and if seller-initiated trading dominates call trading in unsuccessful takeover deals. Two postannouncement periods are considered, a 30-day window and a 60-day window following the announcement day. Panel A of table 8 shows that, in the 30-day window, postannouncement seller-initiated call trading activity increases in both successful and unsuccessful takeover deals. However, the relative increase in seller-initiated call activity is larger and significant in successful takeover targets. The increase in seller-initiated activity could be due to (1) informed traders who bought their options prior to the announcement locking in

TABLE 8 **Summary Statistics of Call and Put Volume Imbalances in the Postannouncement Period**

		[−200, −100]	[+1, +30]	Change	t-Test p-Value	Wilcoxon Test p-Value
A. Postannouncement Period [+1, +30]						
Successful Deals	Calls	−4.34	−27.51	−23.17	.03	.04
	Puts	−5.32	−4.10	1.22	.77	.86
Unsuccessful Deals	Calls	−6.01	−10.47	−4.46	.58	.64
	Puts	−8.23	−14.20	−5.97	.62	.68
B. Postannouncement Period [+1, +60]						
Successful Deals	Calls	−4.34	−21.63	−17.29	.01	.02
	Puts	−5.32	−11.10	−5.78	.18	.52
Unsuccessful Deals	Calls	−6.43	−10.66	−4.23	.52	.81
	Puts	−8.23	−16.26	−8.03	.38	.24

NOTE.—This table presents the cross-sectional averages across firms of the daily call and put volume imbalances (in percent). For calls (or puts) and each day, the imbalance is calculated as the difference between buyer- and seller-initiated volume divided by the average call (or put) volume in the benchmark period [−200, −100]. A trade is classified as buyer-initiated or seller-initiated as follows. Trades occurring in the lower half of the spread, at the bid or below, are classified as sells. Trades occurring at the upper half of the spread, at the ask or above, are classified as buys. Trades at the midpoint of the spread are further classified as a buy (or sell) if the current price is higher (or lower) than the price of previous trade. Trades that are still unclassifiable are identified as cross trades and excluded. The null hypothesis of no difference in the change between the benchmark period and postannouncement period is tested by using the t-test (or the nonparametric Wilcoxon test). The results are reported for successful and unsuccessful deals and for two postannouncement periods: [+1, +30] and [+1, +60].

postannouncement profits, (2) more speculative bearish activity, or a combination of both. Put imbalances for both successful and unsuccessful deals are not significantly different between the postannouncement period and benchmark period. Panel B of table 8 reports option volume activity in the 60-day postannouncement window. We also find that successful takeover targets actually have more investors selling than buying calls.

These postannouncement results differ from the preannouncement ones in that it does not seem that aggregate call activity is informative about the ultimate outcome of the deal. However, it is important to note that the increase in unsigned call and put volume is large in the 30-day and 60-day windows after the takeover announcement compared to that in the benchmark period. For example, the average call (put) volume in the 60-day postannouncement period is about four (five) times as large as that in the benchmark period. It seems likely that this large increase in postannouncement option volume is not due to informed trading. Finally, comparing signed share volume in the benchmark and postannouncement periods, we find no significant changes in share imbalances for both successful and unsuccessful deals. Our postannouncement results are thus consistent with benchmark period findings that suggest no special informative role about future stock price move for option volume during time periods when information asymmetry is expected to be small (a rejection of H3).

V. Robustness Check

Our analysis has included options of various maturities. However, in some cases the maturity of the option may be shorter than the impending takeover announcement date. In such cases, an investor who holds such an option experiences part of the preannouncement takeover price increase but may not experience the full takeover premium. If an investor is highly informed as to the details of an impending takeover and not merely speculating, then it would seem probable that the investor might purchase an option with an expiration going beyond the realized takeover date. Additionally, options with only a few days before expiration may exhibit much different trading activity than during more normal periods. To assess the impact of these issues, we re-examine our key findings prior to takeovers using only those options with more than 30 days (or 7 days) to expiration.

We first turn to re-examining the time-series regression results in the preannouncement period as shown previously in table 2. We do not report these results because they are qualitatively similar to those reported in table 2. Again, in the specification with only lagged order imbalances, share imbalances are positively related to next-day returns in both periods but call order imbalances lead future returns (coefficient 0.038, *t*-statistic of 3.07) only in the preannouncement period. When contemporaneous and lagged imbalances are included in the regressions, only lagged call imbalances (*t*-statistic of 2.24) and not stock imbalances are significant predictors of the next-day return. We also examine results where all options with less than 1 week to expiration are excluded from the analysis and again find similar results.

We next turn to re-examining the cross-sectional regression results with the exclusion of options with less than 30-days to expiration. The results change little from those in table 5. For example, in the regression specification (3) with all control variables, we find that call imbalances are significant predictors of announcement-day returns with a coefficient of 0.23 and a *t*-statistic of 3.05, compared to 0.26 and 3.44 respectively reported in table 5. Other coefficients are similar as well.

We also re-examine the effect of excluding shorter-than-30-day options on the findings based on changes in call and put volumes in table 6 and signed volume changes in table 7. For options with between 30 and 60 days to expiration, the largest increase in preannouncement trading is again in the OTM options, but ATM and ITM options have slightly larger increases in volume than those in table 6. For signed volume (constructed similarly to those in table 7), there is a 218% increase in buyer-initiated volume and only a 141% increase in seller-initiated volume in OTM call options with 30 to 60 days to expiration. Again, the largest increase in buyer-initiated activity is in those short-term OTM call options that will have the largest returns when and if a takeover announcement occurs. Overall, while a restricted sample could lead to less powerful tests, our analyses based on option characteristics indicate that excluding options with less than 30 days (or 7 days) to expiration yields findings similar to those presented in the previous sections.

VI. Out-of-Sample Applications

So far, we documented that signed option volumes are more informative about pending takeover announcements, whereas stock imbalances are more informative about next-day returns during normal periods. This conclusion is based on the takeover sample and thus is in the sample. An interesting question this raises is whether call activity can be used to detect and generate profitable trading strategies in general. In other words, when we go out of the takeover sample and include more stocks (with or without a takeover event), can unusual signed option volume still be a more reliable indicator of pending material informational events than unusual signed stock volume? The logic is that, after establishing call-imbalance (and call-volume) changes as a more informative predictor of pending takeover announcements in the sample, we want to see whether one can extrapolate and apply this finding to a larger sample of firms.

To answer these questions, this section examines several volume-based trading rules, instead of predictive time-series regressions. Our main purpose in the out-of-sample analysis is not to focus on trading profits per se but on the relation between call imbalances (and volume) and subsequent stock returns. While the regression analysis allows us to examine the statistical significance of each ex ante variable, trading profits give us a direct sense of the economic significance of each predictive variable. We use the profitability of a trading rule as a measure of a given signal's economic significance.

Our expanded sample includes all firms with options traded on the CBOE and with at least 1 year of intraday option and stock data between 1986 and 1994. There are 365 firms meeting these criteria. By construction, this sample also includes all those in our takeover sample. For each trading rule, two holding (or forecasting) periods are considered: 2 weeks and 4 weeks. Two trading signals are jointly examined: buyer-seller initiated call volume and unsigned call volume.

To construct a volume-triggered signal, we follow a moving-average rule similar to that used by Brock, Lokonishok, and LeBaron (1992) and Bessembinder and Chan (1998) in their study of technical trading for the Dow Jones Industrial Average. According to our moving-average rule, a buy signal is generated when (1) the short-period moving-average buyer / seller-initiated call volume ratio exceeds the long-period moving-average buy-to-sell ratio by some k_1%; and (2) the short-term daily average call volume exceeds the long-period volume by k_2%, where k_1 and k_2 are predetermined. For our analysis, we use $k_1 = 10\%$, and $k_2 = 25,100$, or 200%.[5] The long period (benchmark period) corresponds to a 100-day window and the short period a 5-day window.[6]

When a buy signal is generated for a firm, call options on the firm with maturities greater than the holding period but less than 60 days are bought in equal quantity (e.g., 1 contract for each call) at the 3:00 P.M. price on the same day. All positions last for a fixed holding period of 2 or 4 weeks. Separate trading instruments are used for each given trading rule, including short-term OTM, ATM, and ITM calls and the underlying stock. Option returns are calculated by taking bid-ask spreads into account—calls are bought at the ask price on the entry day, then sold at the bid price on the last day of the holding period.

A. Call Imbalances and Volume Trigger Rules

Panel A of table 9 reports the daily after transaction cost returns separately from trading short-term OTM, ATM, and ITM calls as well as the underlying stock. Regardless of the instrument used, all trades on the same firm are triggered by the same signal, and hence the number of trades varies only when no short-term call options are traded within a particular moneyness range. With short-term OTM calls as trading instruments, returns from all strategies are positive and significant. In most cases, trading profits are increasing in the volume trigger level. Take the 4-week holding period as an example. The daily returns from the (k_1, k_2) = (10%, 25%), (10%, 100%), and (10%, 200%) call-volume trigger rules are respectively 1.21%, 1.42%, and 1.84%, where short-term OTM calls are the trading instruments. When ATM options are used as the trading instruments, the daily returns are all positive but lower than their counterparts when OTM calls are traded. With ITM calls being traded, the daily returns go down further and become negative, irrespective of the buy-signal trigger level. Finally, if we use the underlying stock (instead of calls) as the trading instrument, the daily returns are near zero. Thus, despite larger percentage bid-ask spreads for short-term OTM calls, they lead to the highest profits based on call-volume signals.

B. Stock Imbalances and Volume Trigger Rules

To compare the information content between the stock and options markets, we examine the trigger rules based on stock imbalances and

5. The average increase in call imbalances is 10.53% in the preannouncement period (see table 1). Therefore, we report results based on $k_1 = 10\%$.

6. The long-period volume calculation stops in the day prior to the short-period window. For the last day of the short-period window, the total volume up until 2:00 P.M. (CST) is used to assess whether a buy is triggered.

TABLE 9 Out-of-Sample Call-Volume- and Stock-Volume-Based Trading Profits

	Trading Instrument (by Holding Period)							
	Short-Term OTM Calls		Short-Term ATM Calls		Short-Term ITM Calls		Stocks	
	2 weeks	4 weeks	2 weeks	4 weeks	2 weeks	4 weeks	2 weeks	4 weeks
A. Returns on Call Positions and Stocks								
Call volume (k_1, k_2)								
(10%, 25%)	.56*	1.21*	−.31	.14*	−.31	−.14	−.04	.00
	{3,335}	{1,649}	{4,350}	{2,388}	{8,520}	{5,336}	{8,702}	{6,412}
(10%, 100%)	.65*	1.42*	−.23	.22	−.33	−.07	−.04	.00
	{1,820}	{983}	{2,431}	{1,450}	{4,750}	{3,226}	{4,846}	{3,880}
(10%, 200%)	.68*	1.84*	−.21	.29*	−.40	−.01	−.04	−.01
	{929}	{515}	{1,254}	{824}	{2,487}	{1,740}	{2,553}	{2,178}
Stock volume (k_1, k_2)								
(10%, 25%)	.05	1.65*	−.34	.18*	−.28	−.10	−.04	.00
	{3,360}	{1,768}	{4,151}	{2,360}	{8,458}	{5,506}	{8,730}	{6,422}
(10%, 100%)	.00	1.11*	−0.41	.16*	−0.30	−0.06	−0.05	.00
	{1,145}	{690}	{1,265}	{810}	{2,720}	{1,980}	{2,934}	{2,581}
(10%, 200%)	−.21	.37*	−.58	.07	−.55	−.02	−.05	−.01
	{400}	{260}	{422}	{305}	{908}	{710}	{1,025}	{952}

B. Returns on Δ_S-Adjusted Call Positions and Stocks

Call volume (k_1, k_2)								
(10%, 25%)	.04*	.13*	−.04	.03*	−.08	−.03	−.04	.00
(10%, 100%)	.06*	.15*	−.04	.05*	−.08	−.03	−.04	.00
(10%, 200%)	.08*	.18*	−.03	.06*	−.11	−.03	−.04	−.01
Stock volume (k_1, k_2)								
(10%, 25%)	−.03	.14*	−.06	.01	−.07	−.03	−.04	.00
(10%, 100%)	−.02	.11	−.07	.00	−.09	−.04	−.05	−.01
(10%, 200%)	−.04	.05	−.08	.00	−.14	−.04	−.05	−.01

NOTE.—For each of the 365 firms used in the out-of-sample test, trading rule profits are calculated for the period from January 1986 through December 1994. The moving average trading rule generates a buy signal when (1) the short-term $[t-5, t-1]$ daily average call (or stock) imbalance ratio (e.g., buyer /seller-initiated volume ratio) exceeds the long-period $[t-106, t-6]$ imbalance ratio by k_1% on day t; and (2) the short-term $[t-5, t-1]$ daily average call (or stock) volume exceeds the long-period $[t-106, t-6]$ by volume k_2% on day t. Following a buy signal, OTM (or ATM, ITM) calls with maturities greater than the holding period but less than 60 days are bought at the closing ask price on day t and liquidated after x weeks ($x = 2$ and 4 weeks) at the closing bid price to calculate trading profits after transaction costs. OTM, ATM, and ITM denote out-of-the money, at-the-money, and in-the-money options, respectively. The average daily trading profit is found by averaging the profits to all call trades for a particular stock each day, then averaging across securities held that day. When the stock is chosen as a trading instrument, it is bought and sold at the end-of-the day price. We then adjust for transaction costs by subtracting an average bid-ask spread of 1.2% (taken from Huang and Stoll 1996). The stock return is calculated as $[(S_{t+x} - S_t)/S_t] \times 100\%$. In panel A, the call-option return is calculated as $[(C_{t+x,\text{bid}} - C_{t,\text{ask}})/C_{t,\text{ask}}] \times 100\%$; while in panel B the call-option return is adjusted for the option's delta and calculated as $[(C_{t+x,\text{bid}} - C_{t,\text{ask}})/\Delta_S S_{t,\text{ask}}] \times 100\%$, where $\Delta_S = \boldsymbol{C}/\boldsymbol{D}$ is estimated using the Black-Scholes model and x is the holding period. The reported numbers are, respectively, the time-series average of daily percentage return and the total number of triggers (in curly brackets) for each trading rule. The null hypothesis that the time-series mean of daily percentage return is zero versus the alternative hypothesis of a positive return (e.g., $H_0: \mu = 0$ versus $H_a: \mu > 0$) is tested using a one-sided t-test, where * indicates that the return is significantly greater than zero at the 5% level.

volume. The trading rules work the same way as for the call-volume-based signals in the preceding subsection, except that the underlying stock imbalances and volume are used to generate a buy signal. The results are also reported in panel A of table 9.

First, the daily returns based on the stock imbalances and volume signals are smaller than the respective returns based on call imbalances and volume signals, irrespective of the volume trigger level and so long as OTM and ATM calls are used as trading instruments (the only exception is the result based on a [10%, 25%] volume trigger). Second, unlike the case of call imbalances and volumebased signals, profits based on stockvolume signals are monotonically decreasing with the volume trigger level (for most trading instruments). Finally, when the underlying stock is used as the trading instrument, both share-volume- and call-volume-based signals produce almost identical daily returns at a given volume trigger level and for either holding period. This result further demonstrates that both the choice of a volume signal and the choice of a trading instrument are important considerations in realizing the value of the information.

The result that the choice of trading instrument matters may simply be a consequence of the different leverage levels offered by options. To examine such a possibility, we first use the delta of the call option ($\Delta_S = \partial C/\partial S$) to convert an option position into a share-equivalent dollar investment (which is equal to the stock price times the option delta), with the understanding that the option delta is an approximate measure of leverage. Then, the delta-adjusted return to an option position is equal to the difference between the option's future liquidation price and its entry price, divided by its delta times the stock's price today. Panel B of table 9 reports the delta-adjusted daily returns. After the delta adjustment, the profit based on call volume signals decreases except that the 4 week holding period profits to holding OTM and ATM calls are still positive and significant. Profits again are increasing in the call-volume trigger. Overall, the patterns discussed previously are preserved and we obtain similar conclusions.

In summary, these out-of-sample analyses indicate that abnormally high call-option activity combined with a large call-volume imbalances generally signals some information about pending firm-affecting events. The more extreme the changes in call volume, the more reliable is the call-volume signal. Such is not the case for stock-volume triggers. Moderate stock-volume increases seem to be a more reliable trading signal than extreme share-volume changes (as the daily returns based on the [10%, 25%] trigger level are higher than those based on the [10%, 100%] or [10%, 200%] trigger). This fact suggests that the options market may be more informative about extreme future events, whereas the stock market is more informative about more moderate future events. This is consistent with our earlier conclusion based on the takeover sample that the stock market is informative during normal periods but the option market is informative during periods of heightened information asymmetry.

VII. Concluding Remarks

In this paper, we examined the relative information content of stock and option volume prior to takeover announcements. In time-series regressions, we find that, during the benchmark period, lagged stock-volume imbalances are more informative of next-day returns and lagged call-volume imbalances are not related to returns. In the preannouncement period, option imbalances become significant predictors of next-day stock returns. We find that this strong relation between preannouncement call imbalances and returns is concentrated in successful takeover targets. We compare firms with and without options and find that, when both options and stocks are available for trading, calls displace information in the preannouncement period that might otherwise be reflected in stock imbalances. In the cross-sectional analysis, we find that large preannouncement increases in call imbalances are associated with higher takeover premiums, while preannouncement increases in share imbalances are not related to future returns. Thus, ahead of major announcements, the options market plays an important role in information revelation, whereas during normal market times, the stock market is the primary place of price discovery.

Among option characteristics, short-term OTM calls (which are also the most profitable) experience the largest increase in volume and buyer-initiated volume. We find that postannouncement trading activity does not predict the future success or failure of a deal. To examine the scope of our conclusions, we included in our out-of-sample exercise all firms that had options traded on the CBOE. Extremely high call-volume trigger rules lead to significantly higher returns. On the other hand, for signals based on share volume, the higher the volume threshold, the lower are the average returns. An implication of these results is that the options market can be particularly informative ahead of extreme material events, while the stock market may be more suitable for disseminating ordinary information flow.

Our findings have implications for 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. Our results indicate that, if information has leaked about a pending takeover, this information is likely to be revealed in the options market first.

These findings also have important implications for policy makers and regulators. While we do not investigate whether the evidence of informed trading is driven by illegal insider trading, one might conjecture 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 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.

From a the market designer's perspective, our evidence shows that it matters what type of security market is available to investors. Some markets such as the underlying stock are more suitable for price discovery during ordinary time periods, so that the usual information flow is gradually and smoothly impounded into prices. Other types of markets, such as options contracts, may play an informative role at times of severe information asymmetry and in advance of extreme events.

References

Amin, Kaushik, and Charles Lee. 1997. Option trading, price discovery, and earnings news dissemination. *Contemporary Accounting Research* 14:153–92.

Anthony, Joseph. 1988. The interrelation of stock and option market trading-volume data. *Journal of Finance* 43:949–61.

Back, Kerry. 1993. Asymmetric information and options. *Review of Financial Studies* 6:435–72.

Barone-Adesi, Giovanni, Keith Brown, and W. V. Harlow. 1994. On the use of implied stock volatilities in the prediction of successful corporate takeovers. *Advances in Futures and Options Research* 7:147–66.

Bessembinder, Hendrik, and Kalok Chan. 1998. Market efficiency and the returns to technical analysis. *Financial Management* 27:5–17.

Black, Fisher. 1975. Fact and fantasy in use of options. *Financial Analysts Journal* 31:36–41, 61–72.

Brock, William, Josef Lakonishok, and Blake LeBaron. 1992. Simple technical trading rules and the stochastic properties of stock returns. *Journal of Finance* 47:1731–64.

Cao, Charles, Hyuk Choe, and Frank Hatheway. 1997. Does the specialist matter? Differential execution costs and inter-security subsidization on the NYSE. *Journal of Finance* 52:1615–40.

Chan, Kalok, Peter Chung, and Wai-Ming Fong. 2002. The informational role of stock and option volume. *Review of Financial Studies* 15:1049–76.

DeMarzo, Peter, Michael Fishman, and Kathleen Hagerty. 1998. The optimal enforcement of insider trading regulations. *Journal of Political Economy* 106:602–32.

Easley, David, Maureen O'Hara, and P. S. Srinivas. 1998. Option volume and stock prices: Evidence on where informed traders trade. *Journal of Finance* 53:431–66.

Huang, Roger, and Hans Stoll. 1996. Dealer versus auction markets: A paired comparison of execution costs on NASDAQ and the NYSE. *Journal of Financial Economics* 41:313–57.

Jarrell, Gregg, and Annette Poulsen. 1989. Stock trading before the announcement of tender offers: Insider trading or market anticipation? *Journal of Law, Economics, and Organization* 5:225–48.

Jensen, Michael, and Richard Ruback. 1983. The market for corporate control: The scientific evidence. *Journal of Financial Economics* 11:5–50.

Keown, Arthur, and John Pinkerton. 1981, Merger announcements and insider trading activity: An empirical investigation. *Journal of Finance* 36:855–69.

Kumar, Raman, Atulya Sarin, and Kuldeep Shastri. 1998. The impact of options trading on the market quality of the underlying security: An empirical analysis. *Journal of Finance* 53:717–32.

Lang, Larry, Rene M. Stulz, and Ralph A. Walkling. 1989. Managerial performance, Tobin's *Q*, and the gains from successful tender offers. *Journal of Financial Economics* 24:137–54.
Lee, Charles, and Mark Ready. 1991. Inferring trade direction from intraday data. *Journal of Finance* 46:733–46.
Mayhew, Stewart, Sarin, Atulya, and Kuldeep Shastri. 1995. The allocation of informed trading across related markets: An analysis of the impact of changes in equity-option margin requirements. *Journal of Finance* 50:1635–54.
Meulbroek, Lisa. 1992. An empirical analysis of illegal insider trading. *Journal of Finance* 47:1661–99.
Mitchell, Mark, and Harold Mulherin. 1996. The impact of industry stocks on takeover and restructuring activity. *Journal of Financial Economics* 41:193–229.
Pan, Jun, and Allen Poteshman. 2003. The information in option volume for stock prices. Working paper, MIT and University of Illinois.
Schwert, William. 1996. Markup pricing in mergers and acquisitions. *Journal of Financial Economics* 41:153–92.
Skinner, Douglas. 1997. Do options markets improve informational efficiency? *Contemporary Accounting Research* 14:193–201.
Stephan, Jens, and Robert Whaley. 1990, Intraday price change and trading volume relations in the stock and stock option markets. *Journal of Finance* 45:191–220.
Vijh, Anand. 1990. Liquidity of the CBOE equity options. *Journal of Finance* 45: 1157–79.
White, Halbert. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48:817–38.