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*

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.

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

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

	Absolute			
Variable	[−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

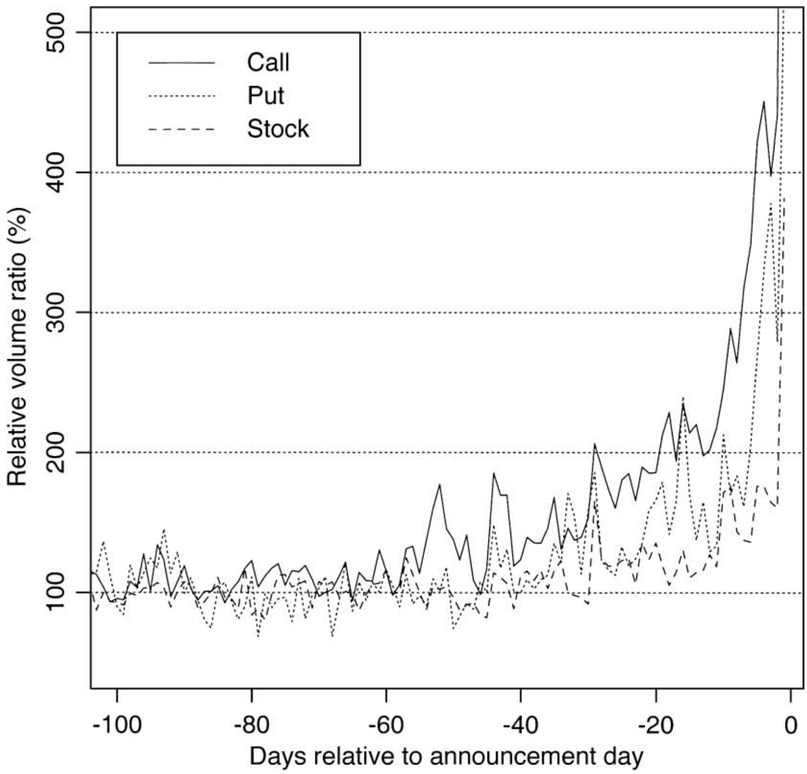

FIG. 1.—Daily ratio of call, put and stock volumes to their respective benchmark period volumes. The time-series of the cross-sectional average call, put and stock volumes is plotted from date −100 to −1, where date 0 is the announcement day. All volume measures are scaled by their respective security 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:

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

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)
$I^{LargeRunup}ShareOI_{t-1}$	−.014	−.004	.024	.010	−.012	−.010	.031	.015
	(−.57)	(−.18)	(.64)	(.30)	(−.45)	(−.36)	(.70)	(.37)
$I^{LargeRunup}CallOI_{t-1}$	−.003	−.005	−.001	−.015	−.001	−.002	−.012	−.025
	(−.14)	(−.23)	(−.02)	(−1.00)	(−.07)	(−.07)	(−.40)	(−1.82)
$I^{LargeRunup}PutOI_{t-1}$	−.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 $[t - 1 \text{ year}, t + 1 \text{ year}]$ 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)
$I^{\mathrm{Op}}\mathrm{ShareOI}_{t-1}$	.034*	(2.34)	.010	(.68)
$I^{\mathrm{Nonop}}\mathrm{ShareOI}_{t-1}$	.027*	(2.07)	−.008	(−.60)
$I^{\mathrm{Op}}\mathrm{CallOI}_{t-1}$	.008	(1.01)	−.009	(−.66)
$I^{\mathrm{Op}}\mathrm{PutOI}_{t-1}$	.001	(.10)	−.004	(−.30)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{ShareOI}_{t-1}$	−.010	(−1.023)	.001	(.03)
$I^{\mathrm{Preann}}I^{\mathrm{Nonop}}\mathrm{ShareOI}_{t-1}$	.019	(1.81)	.041*	(2.27)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{CallOI}_{t-1}$	.030*	(3.03)	.031*	(2.12)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{PutOI}_{t-1}$	−.003	(−.41)	.000	(.02)
$I^{\mathrm{Op}}\mathrm{ShareOI}_{t}^{*}$			.282*	(20.80)
$I^{\mathrm{Nonop}}\mathrm{ShareOI}_{t}$			.340*	(24.80)
$I^{\mathrm{Op}}\mathrm{CallOI}_{t}$			−.084*	(−6.04)
$I^{\mathrm{Op}}\mathrm{PutOI}_{t}$			.015	(1.05)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{ShareOI}_{t}$			−.030	(−1.66)
$I^{\mathrm{Preann}}I^{\mathrm{Nonop}}\mathrm{ShareOI}_{t}$			−.082*	(−3.72)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{CallOI}_{t}$			.171*	(8.63)
$I^{\mathrm{Preann}}I^{\mathrm{Op}}\mathrm{PutOI}_{t}$			−.044*	(−2.32)
Adj. R^2	.012		.109	

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

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

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.