The Information in Option Volume for Stock Prices

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Abstract

We find strong evidence that option trading volume contains information about future stock price movements. Taking advantage of a unique dataset from the Chicago Board Options Exchange, we construct put to call ratios for underlying stocks, using volume initiated by buyers to open new option positions. Performing daily cross-sectional analyses from 1990 to 2001, we find that buying stocks with low put/call ratios and selling stocks with high put/call ratios generates an expected return of 40 basis points per day and 1 percent per week. This result is present during each year of our sample period, and is not affected by the exclusion of earnings announcement windows. Moreover, the result is stronger for smaller stocks, indicating more informed trading in options on stocks with less efficient information flow. Our analysis also sheds light on the type of investors behind the informed option trading. Specifically, we find that option trading from customers of full service brokers provides the strongest predictability, while that from firm proprietary traders is not informative. Furthermore, our analysis shows that while public customers on average trade in the option market as contrarians – buying fresh new puts on stocks that have done well and calls on stocks that have done poorly, firm proprietary traders exhibit the opposite behavior. Finally, in contrast to the equity option market, we do not find any evidence of informed trading in the index option market.

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1 Introduction

For the past several decades, the capital market has experienced an impressive proliferation of derivative securities, ranging from equity options to fixed-income derivatives to, more recently, credit derivatives. Although the notion that derivatives are redundant via dynamic trading of the underlying security is a powerful one [Black and Scholes (1973) and Merton (1973)], the explosive increase in the derivatives market constitutes compelling evidence that derivatives are not completely redundant.

In this paper, we focus on the informational role of derivatives.[1] Specifically, we investigate the extent to which information about underlying securities is present in the trading of their derivatives. The view that informed investors might choose to trade in the option market has long been entertained by academics [e.g. Black (1975)] and can often be found in the popular press.[2] The existing empirical evidence for such a view, however, is mixed. On the one hand, there is evidence that option volume contains information before the announcement of important firm specific news. For example, Amin and Lee (1997) find that a greater proportion of long (or short) positions are initiated in the option market immediately before good (or bad) earnings news on the underlying stock. In a similar vein, Cao, Chen, and Griffin (2002) show that in a sample of firms that have experienced takeover announcements, higher pre-announcement volume on call options is predictive of higher takeover premiums. On the other hand, there is not much evidence that during "normal" times option volume predicts underlying stock prices. At a daily frequency, Cao, Chen, and Griffin (2002) find that during "normal" times, stock volume but not option volume is informative about future stock returns. At higher frequencies such as at 5-minute intervals, there is a microstructure literature which examines the informational content of option volume for future stock price movements. The findings at these higher frequencies are inconclusive. Easley, O'Hara, and Srinivas (1998) report clear evidence that signed option volume contains information for contemporaneous stock prices but less decisive evidence that it contains information for future stock prices.[3] More recently, Chan, Chung, and Fong (2002) conclude that option volume does not lead stock prices.[4]

[1] Derivatives could also be used to hedge additional risk factors such as stochastic volatility and jumps [Bates (2001), Liu and Pan (2003)], to mimic dynamic portfolio strategies in a static setting [Haugh and Lo (2001)], to hedge background risk [Franke, Stapleton, and Subrahmanyam (1998)], and to express differences of opinion [Kraus and Smith (1996), Bates (2001), Buraschi and Jiltsov (2002)].

[2] For example, on July 25, 2002, the *Wall Street Journal* reported that the CBOE was investigating "unusual trading activity" in options on shares of Wyeth, the pharmaceuticals giant based in Madison, N.J., which experienced a sharp increase in trading volume earlier that month. The option volume uptick occurred days before the release of a government study by the Journal of the American Medical Association that documented a heightened risk of breast cancer, coronary heart disease, strokes and blood clots for women who had been taking Wyeth's hormone-replacement drug Prempro for many years.

[3] Their findings about the relationship between option volume and future stock prices are difficult to interpret. Specifically, when they regress stock price changes on positive option volume (i.e., call purchases and put sales), the coefficient estimates on four of six past lags are negative; when they regress stock price changes on negative option volume (i.e., put purchases and call sales) the coefficient on the first lag is positive. Easley, O'Hara, and Srinivas (1998) write about these coefficient signs that "our failure to find the predicted directional effects in the data is puzzling" (page 462).

[4] Other related papers on the information linkage between the option and stock markets include theoretical development by Grossman (1988), Back (1993), Biais and Hillion (1994), Brennan and Cao (1996), John,

In this paper, we take an asset pricing perspective and examine the predictability of option volume over daily and weekly intervals. We contribute to the existing literature by providing strong evidence that option volume in general does contain information about future stock price movements. In particular, we find that put/call ratios constructed from equity option volume are significant predictors of cross-sectional stock returns for at least one week into the future.

Our approach differs from the existing empirical studies along the following three dimensions. First, we take advantage of a unique dataset from the Chicago Board Options Exchange (CBOE) which breaks down the daily trading volume of both call and put options into four categories according to whether a trade is initiated by a buyer or a seller, and whether the initiator opens a new option position or closes an existing option position. Previous studies, by contrast, have either ignored these distinctions all together or used an algorithm like that proposed by Lee and Ready (1991) to infer, with some noise, only whether each trade is buyer or seller initiated. The potential importance of our volume categorization is quite evident. Behind different trading categories are different trading motives, which in turn may contain different informational content. Second, we provide an extensive cross-sectional study using all liquid equity options traded on the CBOE over the 12 year period from 1990 through 2001, while other research has used only several months of data on a small number of underlying firms. For example, Easley, O'Hara, and Srinivas (1998) use data on 50 firms for 44 trading days, while Chan, Chung, and Fong (2002) use data on 14 firms for 58 trading days. Third, the option volume we use in this paper is further classified by investor type into firm proprietary traders, customers of discount brokers, customers of full-service brokers, and other public customers. Given that different types of investors might trade options for different reasons, this additional classification may shed light on the heterogeneity that exists in the option market.

Our main conclusion on informed trading in the option market derives from our analysis of "open buy" volume, which corresponds to trades initiated by buyers to open new option positions. For each underlying stock with at least 50 open buy contracts on a given day, we construct a daily put/call ratio, which is defined as the put volume divided by the put-plus-call volume, using only open buy volume for both puts and calls. Our rationale for focusing on this indicator is simple. If an investor with positive (or negative) information about a stock chooses to trade in the option market, the most straightforward trade is to open a new call (or put) position, which provides leverage with limited liability. Treating this put/call ratio as a possibly informative indicator left behind by option investors, we investigate whether it predicts future stock returns. Specifically, on each trade date, we sort stocks cross-sectionally into quintiles based on their put/call ratios and form a portfolio that buys stocks in the lowest quintile and sells stocks in the highest quintile. We find that this portfolio generates an average next-day return of about 40 basis points with a t-stat of 24. Reducing the cross-sectional sorting to once a week, we find that a hedge portfolio of "buying low" and "selling high" generates an average return of 1% per week with a t-stat of 12. The predictability tapers off after one week, and bi-weekly portfolio formation yields only

Koticha, Narayanan, and Subrahmanyam (2000) and others; and empirical investigations by Manaster and Rendleman (1982), Stephan and Whaley (1990), Vijh (1990), Figlewski and Webb (1993), Mayhew, Sarin, and Shastri (1995), Chakravarty, Gulen, and Mayhew (2002) and others.

a slightly higher average bi-weekly return of 1.1%. It is also interesting that the reported predictability is not driven just by the long or the short side. In fact, returns to "buying low" are similar in magnitude to returns to "selling high." Putting aside the question of whether such a strategy would be profitable after accounting for transaction costs, the strong cross-sectional predictability found in our analysis provides convincing support for the view that a significant amount of information about the underlying stock, both positive and negative, is present in option market trading.

Since our data cover all trades at the CBOE, the open-buy volume contains not only "simple" trades initiated by investors with positive (or negative) information about the underlying stock who buy calls (or puts), but also "complex" trades corresponding to new long option positions opened in conjunction with long or short positions in the underlying stock or other options. The presence of such "complex" trades will add noise to the open-buy volume and also may well bias against its expected informational content.[5] It is important to note, however, that our empirical findings in themselves constitute clear evidence that option volume is informative, and this conclusion is not affected (in particular, is not weakened in any way) by the presence of "complex" trades in the open-buy volume. In addition, we expect the empirical results would be even stronger if our data allowed us to filter out the open-buy volume linked to the "complex" trades.

Although identifying the nature of the informed option market trading that we document is beyond the scope of this paper, our analysis does shed light on the type of investors behind the informed trading. We find that, among our four investor groups, the customers of full service brokers provide the strongest predictability for future stock prices, while the open buy volume from the firm proprietary traders does not exhibit any predictability at all. Moreover, our analysis shows that while the three groups of public customers act as contrarians in the option market — buying fresh new calls on under-performing stocks and buying fresh new puts on over-performing stocks, the firm proprietary traders exhibit the opposite behavior — buying calls on stocks that have done well and puts on stocks that have done poorly.

To ensure that our results are not simply driven by option trading around earnings announcements, we repeat our analysis excluding days within a ±5-trade date window around earnings announcements, and find little change in our results. To exclude the possibility that our results are driven by some extraordinary sub-period within our sample such as the internet boom or bust, we also report our results by year and find the results to be extremely stable across our 12-year sample period. Finally, to ensure that our results are not produced by well-established cross-sectional relation such as size, book-to-market, short-term reversal, intermediate-term momentum, stock trading volume, or analyst coverage, we perform daily cross-sectional regressions using these measures as control variables, and find that the cross-sectional predictability of put/call ratios is not affected in any significant way by their inclusion.

In order to obtain a better understanding of our results, we further examine the put/call ratio predictability across stocks with different levels of efficiency in their information flow. Given that larger firms typically get more attention than smaller firms, one would expect

[5]For example, an investor might exploit his negative information about a stock by shorting the stock and hedging the short position by opening a new long call position. This negative information will translate into a positive signal for the underlying stock by lowering the open-buy put/call ratio for the underlying stock.

that information flow is more efficient in larger firms.[6] Indeed, after sorting the cross-sectional sample into three groups by firm size, we find that the average next-day returns to "buying low and selling high" are 60.5 basis points for small firms, 36 basis points for medium firms, and 17.4 basis points for large firms.[7] Other than size, analyst coverage is an alternative proxy for information efficiency. After controlling for size, however, we do not find that firms with less analyst coverage exhibit higher levels of stock return predictability from option volume.

While we (and to a certain extent the option market makers) are able to see the option volume broken down into our four categories including open-buy and open-sell option volume, the general public sees only the total option volume. To examine the predictability of the put/call ratio formed by the total option volume, we aggregate the option volume across the four categories. We find that the predictability of the put/call ratio is still statistically significant, but the magnitude is less than half of that obtained when only the open buy volume is used.

Finally, our analysis also points out an important distinction between the information in equity option trading and the information in index option trading. Forming time-series of put/call ratios by volume type and investor class using S&P 500, S&P 100, and Nasdaq-100 index option data, we find no predictability for their respective future index returns. This is in direct contrast to our cross-sectional findings for the equity option market. Moreover, using a time-series of market-level put/call ratios that are formed by aggregating, across stocks, all of the put and call data on equity options, we find mixed results on predictability for the CRSP (Center for Research in Security Prices) equal-weighted index returns. In short, while there is clearly informed trading in the equity option market, the trading activity in the index option market does not seem to be informative about future market movements.

The rest of the paper is organized as follows. Section 2 details the data, Section 3 presents our main results and a set of robustness checks, and Section 4 concludes the paper.

2 Data

2.1 The option dataset

The main data for this paper were obtained from the CBOE. The data consist of daily records of trading volume activity for all CBOE listed options from the beginning of January 1990 through the end of December 2001. Each option in our dataset is identified by its underlying stock or index, as a put or call, and by its strike price and time to expiration. In contrast to other option datasets (e.g., the Berkeley Option Data Base and OptionMetrics), one feature that is unique to our dataset is that for each option, the associated daily trading volume is subdivided into 16 categories defined by four trade types and four investor classes.

The four trade types are: "open buys" which are initiated by a buyer to open a new option position, "open sells" which are initiated by a seller to open a new position, "close buys" which are initiated by a buyer to close an existing short position, and "close sells"

[6] The lead/lag effect of Lo and MacKinlay (1990) provides some evidence for such an argument.

[7] It should be noted that our small firms are not small in the usual sense. On average they belong to NYSE-based size decile 4.3. They are only small relative to the group of stocks with active option trading.

Table 1: **Option trading volume by trade type and investor class**

Daily data from 1990/1/2 to 2001/12/31 except where otherwise noted. On each trade date, the cross-section of equity options is sorted by the underlying stock size into small, medium, and large size terciles, and the reported numbers are time-series means of cross-sectional averages. For index options, the reported numbers are time-series averages.

	open buy		open sell		close buy		close sell	
	put	call	put	call	put	call	put	call
Panel A: Equity Options								
Small Stocks								
avg volume	16	53	18	49	8	18	9	26
% from Trader	7.48	4.46	5.42	4.09	4.42	4.84	3.83	3.75
% from Discount	7.35	12.92	9.96	11.97	7.81	11.14	6.74	11.89
% from Full Serv	72.61	71.73	75.84	73.66	77.90	72.09	75.96	71.60
Medium Stocks								
avg volume	38	96	36	89	17	39	21	57
% from Trader	10.87	8.81	9.89	7.62	8.19	8.17	6.76	6.85
% from Discount	8.49	12.48	9.38	9.97	8.67	9.34	9.73	12.27
% from Full Serv	69.22	67.90	71.38	72.37	71.42	69.89	69.36	68.14
Large Stocks								
avg volume	165	359	135	314	66	159	90	236
% from Trader	14.45	11.36	13.61	10.14	11.18	9.86	9.19	8.25
% from Discount	9.77	13.18	7.83	8.02	7.73	7.55	11.31	13.64
% from Full Serv	63.60	64.70	69.68	71.98	68.72	69.95	65.27	65.84
Panel B: Index Options								
S&P 500 (SPX)								
avg volume	17398	10254	12345	11138	7324	7174	10471	6317
% from Trader	23.51	34.29	35.71	25.51	32.51	20.05	20.10	28.24
% from Discount	4.22	4.19	1.38	1.59	1.48	1.72	4.45	4.78
% from Full Serv	58.24	48.16	48.81	59.45	49.75	63.79	59.58	51.72
S&P 100 (OEX)								
avg volume	25545	19112	12825	11900	9024	9401	20232	15870
% from Trader	6.04	11.01	18.13	10.05	19.78	11.07	6.31	10.42
% from Discount	12.32	14.04	4.76	5.06	4.56	5.13	12.49	14.08
% from Full Serv	64.61	58.67	60.52	67.48	54.19	61.84	62.79	56.74
Nasdaq 100 (NDX), from 1994/2/7 to 2001/12/31								
avg volume	1757	1119	1412	1369	815	949	1185	748
% from Trader	22.68	33.25	35.90	22.69	34.22	17.43	16.71	26.50
% from Discount	5.90	9.76	2.85	2.66	4.46	3.02	7.10	11.74
% from Full Serv	62.83	49.61	53.49	65.09	50.95	66.86	65.18	52.23

which are initiated by a seller to close an existing long position. This classification of trade types provides two advantages over the data sets that have been used previously. First, we know with certainty the "sign" of the trading volume. By contrast, the existing literature on the informational content of option trading volume at best infers the sign, with some error, from quote and trade information using the Lee and Ready (1991) algorithm.[8] Second, unlike the previous literature, we know whether the initiator of observed volume is opening a new option position or closing one that he or she already had outstanding. This information may be useful because the motivation and hence the informational content behind trades that open and close positions may be different.

The volume data is also categorized according to which of four investor classes initiates the trades. The four investor classes are: firm proprietary traders (T), public customers of discount brokers (D), public customers of full-service brokers (F), and other public customers (O).[9] For example, clients of E-Trade are labeled as D, while clients of Merrill Lynch are labeled as F. This classification of trading volume by investor type could potentially shed some light on heterogeneity that exists in the option market.

Table 1 provides a summary of option trading volume by trade type and investor class. Panel A details the information for equity options, which are sorted on each trade date by their underlying stock size into terciles (small, medium and large). The reported numbers are the time-series means of the cross-sectional averages, and for the same underlying stock, option volumes associated with different strike prices and times to expiration are aggregated together. From Panel A, we can see that in the equity option market, the trading volume for call options is on average much higher than that for put options, and this is true across the open buy, open sell, close buy and close sell categories. Comparing the total open buy volume with the total open sell volume, we do see that buy volume is slightly higher than the sell volume, but the difference is too small to confirm the common belief that options are actively bought rather than sold by non-market maker investors. For each trade type and for both calls and puts, customers of full-service brokers account for more than half of the trading volume regardless of the market capitalization of the underlying stock.[10] On a relative basis, the firm proprietary traders are more active in options on larger stocks.

Panel B paints a somewhat different picture of the trading activity for the options on three major stock indices. Unlike in the equity option market, the total trading volume for call options is on average similar to that for put options, and in many cases, the call volume is lower than the put volume. Comparing the total open buy volume with the open sell volume, we do see that index options, especially puts, are more actively bought than sold by investors who are not market makers. The customers of full-service brokers are still the dominant player, but the firm proprietary traders account for more trading volume in both

[8]See, for example, Easley, O'Hara, and Srinivas (1998) and Chan, Chung, and Fong (2002).

[9]To be more specific, the Option Clearing Corporation (OCC) assigns one of three origin codes to each option transaction: public customers, firm proprietary traders, and market makers. Our data cover volume from all transactions except for the market-maker designation. The public customer data were subdivided by an analyst at the CBOE into orders that originated from discount customers, full service customers, or other customers. The other customers category consists of all public customer transactions that were not designated by the CBOE analyst as originating from discount or full service customers.

[10]The trading percentages in the table do not sum to 100, because (for sake of brevity) the percentage for the other public customer category, which is 100 minus the sum, has been omitted.

the SPX and NDX markets than they do in the equity option market.

2.2 The merged dataset

Focusing first on the equity options, we begin by splitting the total dataset by trade type into four subsets: open buy, open sell, close buy and close sell. After applying the filtering rule spelled out below, we merge each of the subsets with the CRSP, Compustat and I/B/E/S data. For concreteness, the remainder of this section provides a detailed account of the merged open buy data, which is the most important subset for our analyses.

The open buy subset includes all option trading volume that is initiated by buyers to open new option positions. On each day, we calculate the total open buy volume for each stock. This includes both put and call volumes across all available strike prices and times to expiration. To eliminate less liquid options, we retain only those stocks with total open buy volume of at least 50 option contracts. This is done on a daily basis, so some stocks might disappear from our dataset on certain days because of low option trading activity and then re-appear as a result of increased activity. We next merge this dataset with the CRSP daily data to obtain the daily return and trading volume of the underlying stocks. On any given day, if either variable is missing for a stock, it is eliminated from the cross-section of stocks for that day.

The resulting merged open buy dataset is summarized in Table 2. The first panel provides the time-series average, year by year, of the daily cross-sectional sample size (that is, the number of stocks surviving the above filtering rule), which increases substantially from 91 stocks in 1990 to 359 stocks in 2001, representing an overall expansion of the equity option market.

The second panel in Table 2 summarizes the most important variable for our analysis: the ratio of put volume to put-plus-call volume. For each day, this ratio is calculated for each stock in the cross-sectional sample using only open buy volume. The reported numbers are the time-series mean and standard deviation, year by year, of the cross-sectional averages of "put/(put+call)." The put volume as a percentage of the total volume is on average around 30%, which is consistent with our earlier observation that in the equity option market, the trading volume for call options is on average higher than that for put options. It is also interesting to see that this ratio is lower during the late 1990s and peaked in 1990 and 2001.

The third panel of Table 2 summarizes the ratio of option trading volume to stock trading volume. This variable is scaled so that one unit of option volume is on one share of the underlying stock. The reported numbers are around 10 basis points. This is consistent with the well-known fact that the trading activity in the equity option market is only a tiny fraction of that in the underlying equity market.

The fourth panel of Table 2 reports the market capitalization of our cross-sectional sample of stocks relative to the NYSE stocks. Each month we sort all stocks listed on the NYSE by their market caps into ten groups, with the bottom decile corresponding to the smallest stocks, and the top decile corresponding to the largest stocks. Using these NYSE-based decile breakpoints, we categorize the stocks in our sample according to their market caps into the appropriate deciles. Table 2 indicates that stocks in our sample are typically large stocks, which is not surprising since these are stocks with active option trading. Also, with

Table 2: **Summary characteristics of merged open buy data**

Daily cross-sections from 1990/1/2/ to 2001/12/31 are formed by stocks with at least 50 contracts of open buy volume on that day. The cross-sectional sample size is reported by its time-series mean, minimum and maximum. The put/(put+call) ratio is the put trading volume divided by the total (put plus call) trading volume, where only open buy volume is used. For the put/(put+call) ratio, the NYSE-based size and book-to-market deciles, and the momentum deciles, the time-series means and standard deviations of the cross-sectional averages are reported. For the analyst coverage, % n.c. is the time-series average of the percentage of the cross-sectional sample with no analyst coverage, and mean and median are the time-series averages of the cross-sectional mean and median.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	cross-sectional sample size											
mean	91	92	109	140	155	187	221	275	300	357	460	359
min	47	58	69	102	100	98	123	140	221	256	240	171
max	124	136	150	196	214	253	345	436	394	540	625	498
	put/(put+call) ratios (%)											
mean	34.9	31.5	26.6	27.6	26.2	24.7	23.3	22.5	25.2	22.2	24.3	38.4
std	8.1	6.1	5.3	4.4	4.0	3.7	4.0	4.4	5.9	3.9	5.7	4.6
	option trading volume/stock trading volume (bps)											
mean	14.5	11.4	8.9	8.8	8.9	7.6	6.5	6.8	5.9	4.7	5.0	3.1
std	3.0	2.1	1.6	1.4	1.9	1.8	1.7	2.1	1.4	1.1	8.2	0.7
	NYSE-based size deciles (1=small, 10=big)											
mean	8.6	8.5	7.9	7.5	7.2	7.0	6.8	6.7	6.8	7.1	7.8	7.7
std	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	NYSE-based book/market deciles (1=low, 10=high)											
mean	3.7	3.5	3.1	2.9	2.9	2.8	2.9	3.1	3.1	2.5	2.2	3.1
std	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.1	0.2
	momentum deciles (1=past loser, 10=past winner)											
mean	6.3	6.3	5.7	5.9	5.7	6.5	5.8	5.8	5.8	6.5	6.1	5.0
std	0.3	0.6	0.5	0.3	0.3	0.3	0.4	0.3	0.5	0.6	0.4	0.4
	analyst coverage (no coverage = 0)											
% n.c.	0.8	0.4	3.1	4.0	3.9	3.3	3.9	3.8	4.3	5.3	4.6	4.6
mean	23.5	22.4	18.5	17.1	16.3	14.8	13.4	13.2	13.5	13.4	13.6	14.7
median	23.7	21.9	18.4	15.9	14.4	12.6	11.3	11.0	11.8	11.7	12.0	14.2

the expansion of the equity option market in the mid and late 90s, the average market cap of our sample stocks decreases slightly.

The fifth panel of Table 2 reports the book-to-market ratio of our cross-sectional sample of stocks relative to the NYSE stocks. The book-to-market ratios are formed according to Fama and French (1992), and similar to the size deciles, the breakpoints for the book-to-market deciles are formed based on NYSE listed stocks. The bottom book-to-market decile corresponds to low book-to-market or "growth" stocks, while the top decile corresponds to high book-to-market or "value" stocks. As shown in Table 2, the average book-to-market decile of our sample stocks is around 3.

The sixth panel of Table 2 reports the ranking of our sample stocks in terms of momentum deciles. Following Jegadeesh and Titman (1993), we sort all stocks in the CRSP universe by their past six-month cumulative returns that ended one month ago. The bottom momentum decile corresponds to past "losers," while the top decile corresponds to past "winners." Using these breakpoints, we then put our sample stocks into the appropriate decile. As shown in Table 2, the average momentum decile of our sample stocks is around 6.

The last panel of Table 2 reports the level of analyst coverage for our sample stocks. Using the I/B/E/S historical summary file, we obtain the number of I/B/E/S analysts covering each stock. Stocks with no I/B/E/S analysts are assigned a coverage number of zero. From Table 2, we see that only a small fraction of our stocks have no analyst coverage, while most of the stocks in our sample have a significant number of analysts covering them.

In the interest of brevity, we omit the summary tables for the merged open sell, close buy, and close sell datasets, which are less important for our later analysis. The filtering rules for these datasets are identical to those described above and the basic characteristics of these three datasets are similar to those reported in Table 2. Finally, to merge index options with the underlying index returns, we use the CRSP database to obtain daily returns on the S&P 500 index, the NASDAQ-100 composite index, and the value-weighted and equal-weighted CRSP indices. We use Datastream to obtain daily returns on the S&P 100 index.

3 Results

3.1 Information in open buy volume, a cross-sectional analysis

For investors with positive (or negative) information on a stock, the simplest option trade is to buy a new call (or put), which provides leverage with limited liability. For this reason, we focus first on the informational content of "open buy" volume, which corresponds to trades initiated by buyers to open new option positions. Specifically, we construct a simple measure of put/call ratio — the put trading volume divided by the option (put plus call) trading volume — to capture the potential information embedded in such option trades.[11] Details of the merged open buy data are provided in Section 2.2 and Table 2.

[11] We use put/(put+call) instead of the more widely used measure of put/call so that the variable remains finite when open buy call volume is zero. Having a variable that does not become infinite is important for our regression analyses later in the section. For the present analyses involving put/call-ranking, however, these two measures are equivalent, since the relation between the two variables is monotonic.

Table 3: **Average daily returns on portfolios ranked by put/call ratios using open buy volume**

Portfolios are formed by sorting stocks according to their put/call ratios into quintiles on a daily basis from from 1990/1/2 to 2001/12/31. Only trades initiated by buyers to open new put or call positions are used. Panel A reports the average daily returns to the five put/call-ranked (PC) portfolios, from low PC to high PC. Panel B reports the average daily returns to buying low-PC and selling high-PC portfolios. Panel C repeats Panel B after excluding trade dates within 5 business days of an earnings announcement, EAD.

	day relative to portfolio formation															
t	-5	-4	-3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$+5$	$+6$	$+7$	$+8$	$+9$	$+10$
Panel A: average daily returns of PC-ranked portfolios (in basis points)																
low PC	1.7	0.7	-0.8	2.2	12.1	31.4	25.0	15.5	12.1	11.4	10.2	9.3	6.9	8.7	7.2	7.8
PC 2	-1.6	-2.4	-1.8	-3.9	2.3	28.6	27.2	12.1	8.3	6.8	6.1	7.3	3.7	4.2	4.6	3.9
PC 3	7.9	7.6	5.9	6.6	9.6	15.5	12.5	7.1	6.1	5.4	5.6	4.6	4.6	5.2	6.4	3.6
PC 4	15.6	16.9	17.4	18.2	19.6	13.0	-0.3	3.1	2.1	6.4	4.7	5.2	6.4	6.1	5.1	7.2
high PC	14.5	15.4	17.8	18.0	16.1	-5.9	-14.6	-6.1	-0.8	-0.7	1.4	3.2	4.3	4.0	4.3	3.7
Panel B: average daily returns of low-PC minus high-PC (in basis points)																
	-12.8	-14.7	-18.6	-15.8	-3.9	37.4	39.6	21.6	12.9	12.1	8.8	6.2	2.6	4.7	2.9	4.1
t-stats	-8.04	-9.08	-11.46	-9.44	-2.24	19.77	23.79	13.11	8.18	7.77	5.50	3.86	1.67	2.94	1.80	2.62
Panel C: same as Panel B, excluding EADs and $\pm$5-day windows																
	-11.3	-13.6	-17.0	-14.5	-1.7	37.4	38.0	19.7	12.7	13.2	9.5	7.1	3.8	5.9	2.0	4.0
t-stats	-6.54	-7.86	-9.56	-8.15	-0.90	18.19	21.33	11.11	7.46	7.79	5.38	4.00	2.17	3.26	1.13	2.25

In order to investigate whether information is embedded in the put/call ratios, we sort, on each day in our sample period, the cross-section of stocks into quintiles based upon their put/call ratios. We then form equal-weighted portfolios using stocks contained in each quintile, and track the portfolio returns for the next day, the day after, etc. We repeat this procedure for each day in our sample, and Panel A of Table 3 reports the average daily returns of the five put/call-ranked portfolios from five days before to ten days after portfolio formation.

Focusing first on the post-formation portfolio returns, we see that stocks with relatively more open buy put trading perform worse on average than stocks with relatively more open buy call trading. In other words, higher than average buying of fresh new puts is bad news for a stock, while higher than average buying of fresh new calls is good news. To be more specific, the next-day average return of the highest put/call-ranked portfolio is −14.6 basis points. In contrast, the next-day average return of the lowest put/call-ranked portfolio is 25 basis points. This pattern of decreasing returns with increasing put/call-ranking is quite stable across the five portfolios and persists for at least 5 days after portfolio formation. Moreover, our results are not driven just by the positive side or just by the negative side of the trades. Specifically, for our sample period, the average daily return (cum. dividend) is 11.5 basis points for the CRSP equal-weighted portfolio, and 5 basis points for the CRSP value-weighted portfolio. Using these portfolio returns as a reference point, the returns from our highest and lowest put/call-ranked portfolios are symmetric in magnitude. In short, our findings are consistent with investors trading in the option market to exploit both positive and negative information about the underlying stock.[12] Thus, unlike the empirical findings in Easley, O'Hara, and Srinivas (1998), our results support the directional prediction of that paper's theoretical model regarding informed trading in the option market.

We next examine the expected return to a zero-investment hedge portfolio that is formed by buying the low-PC portfolio and selling the high-PC portfolio.[13] To some extent, the returns to such a hedge portfolio provide a picture of the potential profitability (without accounting for transaction costs) of our put/call strategy.[14] From Panel B of Table 3, we see that the daily expected return of such a hedge portfolio is 39.6 basis points on the day after portfolio formation, 21.6 basis points two days after (i.e., skipping a day), and 12.9 basis points three days after (i.e., skipping two days). These returns have t-stats that range from 8 to 24, and the statistical significance persists well into 10 days after portfolio formation, although the magnitude of the associated daily returns tapers off after 5 days. If instead of

[12]We should also mention that one potential alternative explanation for the findings in Table 3 is price pressure from market-makers hedging their option positions in the stock market. Given that option trading is only a tiny fraction of the trading in the underlying stock market (See Table 2), this price pressure is expected to be small. There are two further reasons why it is unlikely that this price pressure produces our results. First, market-makers hedge their short call positions on the day they enter into them. As a result, part of the day 0 positive return may be due to market-maker hedging, but the positive returns on day +1 and later occur after the hedging has been completed. Second, if any of the positive return on the underlying stock comes from price pressure associated with hedging, we would expect to see the return subsequently reverse. As can be seen in Table 3, at least over the next ten trade dates there is no such reversal.

[13]Here and where it is convenient, we abbreviate put/call by PC.

[14]Since investors do not have ready access to open buy option volume data, we do not carry out an analysis of whether the documented portfolio returns survive transaction costs.

daily rebalancing, we use the option trading information only once every 5 business days, the average return to buying low-PC and selling high-PC is about 1% per week (with a t-stat of 12). If we further reduce the portfolio formation to once every 10 business days, the average bi-weekly return to buying low-PC and selling high-PC increases only to 1.1% (with a t-stat of 7).

To gain some understanding of what triggers the purchase of new put and call options, we examine the returns of PC-ranked portfolios prior to portfolio formation, which are also reported in Table 3. The patterns across PC-ranking before portfolio formation are not as regular as those after portfolio formation. Nevertheless, comparing the returns between the low-PC and high-PC portfolios, we see that the high-PC portfolio is preceded by relatively high returns while the low-PC portfolio is preceded by relatively low returns. This trading pattern of buying puts on stocks that have done well and calls on stocks that have done poorly is consistent with a contrarian strategy on the part of option buyers.

Table 3 also reports the PC-ranked portfolio returns on the portfolio formation day. The contemporaneous relation is similar in pattern and magnitude to that reported on day +1, indicating a potentially interesting contemporaneous interaction between option trading activity and the underlying market movements. The current evidence rules out an absolute lead/lag relationship between option trading and the underlying stock returns. We will revisit this issue when we perform robustness checks in the next subsection.

Finally, Table 4 reports additional information on some basic characteristics of the 5 PC-ranked portfolios. Panel A begins by reporting the average put/(put+call) ratios of the 5 PC quintiles. The "option/stock" volume ratio indicates that the option trading activity is only a tiny fraction of the underlying stock trading activity, and this variable seems stable across the five PC-ranked portfolios. Moreover, the 5 PC-ranked portfolios are also similar in size, book-to-market, and momentum deciles. In particular, there is not a monotonic relationship across the PC rankings. Compared with the low-PC portfolio, the high-PC portfolio is comprised of stocks that on average are bigger in size, lower in book-to-market, and higher in rank as a past winner, although the differences are only in the neighborhood of one decile. In Section 3.2.6, we will use these cross-sectional measures as control variables in cross-sectional regressions to see whether they have any effect on the results.

To assess the daily turnover of the five PC-ranked portfolios, Panel B of Table 4 reports the average daily transition probability across the 5 PC-ranked portfolios. Among the five portfolios, the lowest and highest PC-ranked portfolios turn out to have the lowest turnover rates. For example, with an average probability of 57.53%, a stock in the low-PC portfolio will remain in the low-PC portfolio on the following day. Similarly, the average probability that a stock will remain in the high-PC portfolio from one day to the next is 41.86%. For comparison, the corresponding average probabilities are 25.16%, 30.55%, and 32.38% for the PC2, PC3, and PC4 portfolios, respectively.

3.2 Information in open buy volume, robustness checks

3.2.1 Earnings announcement related effects

We start our robustness checks by determining whether the results reported in Table 3 are driven by option trading activity around earnings announcement dates (EADs). In order to

Table 4: **Summary statistics of merged open buy data, by PC ranking**

Daily cross-sections from 1990/1/2 to 2001/12/31 formed by stocks with at least 50 contracts of open buy volume. Time-series statistics of cross-sectional averages are reported.

Panel A: Summary Statistics of PC-ranked Portfolios

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 1	PC 2	PC 3	PC 4	PC 5
	put/(put+call) ratios (%)					option volume/stock volume (bps)				
mean	0.1	3.1	15.0	38.4	79.7	7.9	7.8	6.9	7.0	8.8
std	0.8	4.7	9.7	13.8	9.9	5.9	7.3	4.6	4.4	11.0
	NYSE-based size deciles					NYSE-based book/market deciles				
mean	6.6	6.6	8.0	8.2	7.8	3.6	3.1	2.8	2.7	2.8
std	0.8	1.4	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	momentum deciles					average number of analyst coverage				
mean	5.7	5.4	6.1	6.3	6.2	13.5	13.8	18.3	18.8	16.6
std	0.7	0.9	0.8	0.8	0.7	3.4	5.7	4.0	3.5	3.2

Panel B: Average Daily Transition Probability (%) across PC-Ranked Portfolios

from portfolio	to PC1	to PC2	to PC3	to PC4	to PC5	drop out
PC1	57.53	9.37	12.36	8.87	11.43	0.44
PC2	32.48	25.16	18.41	12.61	11.03	0.31
PC3	4.50	27.80	30.55	23.76	13.29	0.10
PC4	2.55	19.09	24.36	32.28	21.59	0.14
PC5	2.34	18.54	14.33	22.59	41.86	0.34

do this, we obtain quarterly EADs from Compustat. We then re-construct the merged open buy data as detailed in Section 2.2, except that stocks are excluded from the cross-sectional sample on days that are within five trade dates of one of their EADs. Applying the same cross-sectional analysis to this EAD-filtered dataset, Panel C of Table 3 shows that excluding days within 5 trade dates of an EAD has very little affect on our results. The average return for the +1 and +2 days change by only a couple of basis points, there is no change for the +3 day, and slight increases for the +4 through +8 days. In short, the information transmission captured in our earlier exercise is not driven by EAD-related activity.

3.2.2 Results at annual level

To check whether our results are driven by some extraordinary sub-periods of our sample (e.g., the boom during the late 1990s or the subsequent bust in 2000 and 2001), we report our earlier results year by year from 1990 to 2001 in Table 5. For brevity, only the average daily returns to buying low-PC and selling high-PC portfolios are reported. From Table 5, we see that the main results for day +1 through day +5 are present in each of the 12 years from 1990 through 2001. On average, the associated t-stats reduce by a factor of $\sqrt{12}$ as is expected, since the sample has been shortened by a factor of 12.

Our earlier findings concerning the portfolio returns leading up to and contemporaneous with portfolio formation are not consistently observed at the annual level. Specifically, our earlier finding of contrarian trading on the part of option investors does not apply to 1990; nor does it apply to a number of other years if we focus on the day prior to portfolio formation. We will return to this point when we consider the returns of portfolios formed on the basis of the trading of different types of investors.

3.2.3 The effect of closing time differences

The year by year results can also help us to address a concern that arises because the CBOE option market closes each day after the underlying stock market. The difference in closing time raises the possibility that part of our result for day +1 reflects information that is released after the stock market closes but while the option market is still open. It is possible that such information is, in fact, reflected simultaneously in both the option market volume and in stock prices (in the aftermarket) on the portfolio formation date, but that our methodology makes it appear that the option market volume on the portfolio formation date is informative for next day stock prices.[15] Fortunately, there was a change in the closing time of the CBOE market during our sample period which makes it possible to assess whether it is likely that any appreciable part of our day +1 result is driven by the difference in the closing time of the option and underlying stock markets. In particular, prior to June 23, 1997, the closing time for CBOE options on individual stocks was 4:10 pm (EST), 10 minutes after the closing of the cash market. On June 23, 1997, the CBOE moved the closing time for options on individual stocks to 4:02 pm (EST), 2 minutes after the closing of the underlying stock market. This change was made in an effort to eliminate market disruptions that were

[15] This is because we compute the stock return for day +1 from the closing stock prices on day +0 and day +1.

Table 5: **Returns to buying low-PC and selling high-PC ranked portfolios, by year**

	day relative to portfolio formation															
	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
Panel A: average daily returns (in basis points)																
1990	6.1	5.3	3.1	10.8	18.7	58.3	18.5	18.5	14.2	8.2	10.0	2.7	-2.6	0.7	4.0	-4.7
1991	5.8	-0.7	-7.6	-4.3	22.4	38.3	36.1	20.2	12.3	3.7	3.4	4.4	3.5	-1.0	6.7	1.0
1992	-12.2	-8.1	-14.7	-2.8	2.8	52.6	28.6	15.4	8.6	14.0	5.4	1.0	-1.4	13.1	-3.2	1.2
1993	-5.7	-8.8	-8.8	-13.9	0.9	60.7	43.4	25.5	13.0	15.4	8.6	11.8	-2.2	0.9	1.4	9.8
1994	-10.2	-13.6	-16.1	-17.6	0.3	45.6	40.5	16.8	11.4	14.2	9.2	-7.5	-3.2	6.1	1.2	4.3
1995	-8.8	-14.1	-17.0	-14.7	-9.3	47.5	40.4	20.6	9.3	9.2	6.4	10.3	6.8	-4.8	4.8	5.5
1996	-19.6	-16.4	-21.7	-23.8	-13.3	48.0	48.0	32.1	13.8	10.6	9.1	1.3	8.3	4.0	-1.9	-1.6
1997	-6.2	-13.5	-9.4	-11.6	0.7	49.4	47.0	23.7	20.6	15.4	14.2	19.0	10.7	9.8	4.4	9.4
1998	-25.2	-24.4	-26.0	-19.0	-6.9	36.7	48.3	24.5	22.0	10.0	6.5	1.3	7.5	5.5	-2.8	-0.0
1999	-22.5	-21.7	-32.5	-26.7	-14.5	15.6	43.9	23.9	10.4	14.4	17.5	3.3	4.5	10.1	5.8	5.2
2000	-38.6	-48.8	-56.2	-46.7	-48.9	-34.5	39.5	20.5	8.5	11.7	1.5	12.4	-2.1	2.2	3.3	6.4
2001	-16.5	-11.9	-16.6	-19.3	-0.1	29.9	40.6	17.7	10.9	18.5	13.9	14.4	1.6	10.6	11.2	13.3
Panel B: *t*-stats																
1990	1.17	1.08	0.64	2.17	3.53	9.32	3.39	3.52	2.40	1.66	1.97	0.46	-0.50	0.14	0.85	-0.94
1991	1.08	-0.13	-1.36	-0.71	3.84	6.40	6.72	3.39	2.34	0.66	0.61	0.78	0.66	-0.18	1.15	0.19
1992	-2.14	-1.50	-2.77	-0.50	0.50	9.36	5.46	3.00	1.70	2.45	0.97	0.18	-0.26	2.41	-0.53	0.23
1993	-1.17	-1.83	-1.93	-2.71	0.18	11.10	8.10	5.29	2.47	3.28	1.82	2.48	-0.50	0.17	0.29	2.05
1994	-2.05	-2.74	-3.14	-3.48	0.06	8.00	7.66	3.19	2.41	2.97	1.85	-1.43	-0.72	1.26	0.26	0.87
1995	-2.02	-3.06	-3.50	-2.85	-1.84	8.30	7.69	4.19	1.94	2.00	1.31	2.21	1.48	-0.97	1.01	1.17
1996	-3.85	-3.47	-4.14	-4.45	-2.45	8.18	9.19	5.89	2.91	2.13	1.88	0.29	1.62	0.82	-0.38	-0.32
1997	-1.33	-2.68	-1.97	-2.40	0.13	8.65	9.65	4.98	4.22	3.35	2.89	4.01	2.25	2.07	0.95	2.05
1998	-4.07	-4.05	-4.14	-3.04	-1.06	4.80	7.46	4.26	4.05	1.84	1.26	0.23	1.33	0.95	-0.52	-0.00
1999	-3.66	-3.52	-5.06	-4.34	-2.14	2.27	7.43	4.00	1.89	2.46	2.79	0.52	0.75	1.60	0.92	0.93
2000	-6.06	-7.22	-8.46	-6.45	-6.71	-4.47	5.80	2.74	1.20	1.71	0.20	1.86	-0.28	0.29	0.46	0.89
2001	-2.69	-1.66	-2.55	-2.95	-0.02	4.05	5.58	2.46	1.66	2.95	2.17	2.28	0.25	1.62	1.76	2.21

occurring when news announcements, particularly earnings reports, were made when the option market was open and the underlying stock market was closed.[16] Consequently, if an important part of our day +1 result occurs because of the difference in the closing time of the two markets, we would expect to see the day +1 result decline significantly after June 23, 1997. Since the year by year results reported in Table 5 show no such decline, we believe that it is unlikely that the difference in closing times has any important impact on our findings.

3.2.4 Results by firm size

We examine our results by firm size in order to answer two questions. First, could our results be driven by some lead/lag interaction between small and large firms? Second, given that larger firms typically get more attention, is there a difference in the information of option volume across firm size?

To address these questions, we first sort our daily cross-sectional sample into terciles by firm size, and then repeat the same cross-sectional analysis as in Section 3.1 for each size group. The results are reported in Panels A and B of Table 6. Before summarizing our results, it should be noted that the stocks in our small size group are small only relative to the sample of stocks with actively traded options. In fact, the NYSE-based size decile is, on average, 4.3 for our small size group, 7.8 for our medium size group, and 9.8 for our large size group.

The results reported in Table 6 indicate that within each size group, there is still a significant amount of information transmission from the open buy volume on options to the underlying stock market, and that the effect persists for at least 5 days after portfolio formation. This indicates that our results are not driven by lead/lag interactions across small and large stocks.

Across the size groups, the first day effect is the strongest for the small stocks and weakest for the large stocks. The results for the medium size group are similar to our full sample results. The findings on the size groups are consistent with the intuition that for large stocks there should be less predictability available from option trading because information flow is more efficient for these stocks. Finally, we also notice that compared with the full sample results, the overall t-stats decrease by a factor of 1.5 to 2. This is largely due to the fact that our cross-sectional sample size has shrunk by a factor of 3.

3.2.5 Results by investor class

As explained earlier, our dataset is unique not only in that it contains information about the type of option trades, but also in that it provides information about the type of investors who initiate trading volume. Specifically, the option volume data is categorized into four investor classes: firm proprietary traders (T), public customers of discount brokers (D), public customers of full-service brokers (F), and other public customers (O). (See Section 2.1 and Table 1 for more detailed information.)

We take advantage of this additional layer of information by separating the open buy data into four groups by investor class. Applying the same filtering rule (that is, at least

[16] The closing time of 4:15 pm (EST) for options on nine broad market indices including the S&P 100 (OEX), S&P 500 (SPX), and Nasdaq-100 (NDX) was unaffected.

Table 6: **Returns to buying low-PC and selling high-PC ranked portfolios, by firm size and investor class**

In Panels A and B, the cross-section of stocks is first sorted by size into small (S), medium (M), and big (B), and then sorted by put/call ratios into quintiles. The average NYSE-decile is 4.3 for small, 7.8 for medium, and 9.8 for big size groups. Within each size group, a portfolio is formed by selling stocks in the top put/call quintile and buying stocks in the bottom put/call quintile. Only open buy volume is used. In Panels C and D, the portfolios are formed by selling stocks in the top-quintile put/call ratios and buying stocks in the bottom-quintile put/call ratios, using open buy volume from four investor classes: firm proprietary traders (T), customers of discount brokers (D), customers of full service brokers (F), and others (O). Daily data from 1990/1/2 to 2001/12/31 are used.

	day relative to portfolio formation															
	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
Panel A: average daily returns (in basis points) by firm size																
S	-12.6	-13.3	-15.9	-11.7	9.3	93.7	65.0	27.3	17.1	15.4	6.3	14.0	-0.2	4.6	7.3	4.8
M	-20.5	-21.2	-23.1	-22.5	-14.4	22.6	35.4	18.1	11.9	8.1	6.4	2.4	2.5	0.3	0.3	3.4
B	-12.7	-14.4	-19.7	-18.2	-12.6	1.0	18.0	11.3	5.9	5.3	2.6	2.3	0.4	0.7	-0.8	-1.7
Panel B: t-stats																
S	-3.59	-3.74	-4.54	-3.15	2.33	21.56	17.41	7.73	4.93	4.39	1.87	3.97	-0.06	1.36	2.14	1.43
M	-9.20	-9.26	-10.22	-9.86	-6.18	9.41	15.86	7.76	5.21	3.63	2.81	1.10	1.13	0.13	0.12	1.54
B	-7.89	-9.23	-12.61	-11.36	-7.99	0.60	11.26	6.98	3.73	3.29	1.65	1.46	0.25	0.46	-0.47	-1.05
Panel C: average daily returns (in basis points) by investor class																
T	6.7	16.8	17.3	34.9	47.7	63.1	1.1	-0.2	1.9	1.9	-0.5	3.5	1.7	-1.4	2.2	4.5
D	-25.9	-29.5	-41.5	-39.7	-42.7	-49.8	22.7	10.1	9.7	3.9	3.3	-1.9	-0.9	3.4	0.6	-2.1
F	-12.4	-17.2	-18.7	-17.5	-6.4	39.9	41.1	22.0	16.5	11.7	8.6	7.4	3.6	3.3	3.2	4.6
O	-13.7	-10.6	-19.0	-16.1	-2.0	31.7	32.9	13.1	8.9	3.0	8.6	6.5	-1.1	-0.4	-0.1	-2.4
Panel D: t-stats																
T	1.97	4.91	4.81	9.01	12.07	14.39	0.30	-0.06	0.55	0.57	-0.14	1.05	0.52	-0.42	0.64	1.42
D	-8.61	-9.91	-13.27	-12.57	-11.91	-13.39	7.28	3.40	3.33	1.34	1.13	-0.66	-0.31	1.11	0.19	-0.68
F	-7.16	-9.68	-10.66	-9.64	-3.32	19.38	23.11	12.45	9.59	7.04	4.93	4.32	2.16	1.85	1.83	2.72
O	-4.17	-3.27	-5.44	-4.82	-0.55	8.10	10.07	4.13	2.83	0.89	2.88	2.09	-0.37	-0.13	-0.05	-0.78

50 open buy contracts on an underlying stock to retain it for a particular trade date) to each subset,[17] we repeat separately our cross-sectional analysis for each investor class. The results are summarized in Panels C and D of Table 6.

Our results show that among the four investor classes, the open buy volume from customers of full-service brokers provides the strongest predictive power in both magnitude and statistical significance. This finding is not surprising, since, as can be seen from Table 1, the full-service investors account for about 70% of the total open buy volume. The open buy volume from the customers of discount brokers and others public customers provide some predictability, but it is not as strong as that from the customers of full-service brokers. The open buy volume from firm proprietary traders, on the other hand, is not informative at all about future stock prices. It is important to note that our results speak only to the issue of whose open buy volume is informative and not to the more general issue of which option market participants are informed. It is possible that firm proprietary traders possess information about the underlying stocks but that it is not revealed in their aggregate open buy volume, because they use the exchange-traded option market primarily for hedging purposes. It is also intriguing that the day 0 return for the firm proprietary trader hedge portfolio is a large 63.1 basis points. This may indicate that firm proprietary traders bring information to the option market which is incorporated into the stock price on the same day. We cannot, however, determine whether this is the case from our data, because on day 0 we do not know whether the option volume precedes the stock price change or vice versa. Furthermore, even if the option volume occurs first, part of the positive stock return may be due to the market makers hedging in the stock market as discussed above.

There is also an interesting difference across the investor classes in the pre-formation portfolio returns. The pre-formation returns for the firm proprietary traders are positive, implying that stocks in their low-PC portfolios outperformed stocks in their high-PC portfolios. In other words, the firm proprietary traders buy relatively more new calls on stocks that have done well recently and relatively more new puts on stocks that have done poorly recently. This type of option trading behavior, which is akin to momentum trading, is in direct contrast to the contrarian behavior of public customers, who tend to buy calls on under-performing stocks and buy puts on over-performing stocks.[18] Finally, the difference in the pre-formation portfolio returns across the investor classes may well account for the fact that the aggregate pre-formation portfolio returns were not robust across the years in Table 5 above.

3.2.6 Daily cross-sectional regressions with control variables

To ensure that our results are not caused by some well-established cross-sectional relations such as size, book-to-market, short-term reversal, intermediate-term momentum, trading volume, or analyst coverage, we perform daily cross-sectional regressions using these as

[17] We experimented with different cutoff levels for different investor classes. For example, instead of requiring 50 open buy contracts on a trade date, we repeated our analysis lowering the bar to 20 open buy contracts. The basic findings were robust to these variations.

[18] One could speculate that the firm proprietary traders use exchange-traded options mainly to hedge their existing stock positions. Without observing their stock positions directly, however, we cannot be confident that this is the case.

Table 7: **Daily cross-sectional regressions of future stock returns on put/call ratios**

The daily cross-sectional sample consists of stocks with at least 50 contracts of open buy volume on their options. Daily stock returns (in basis points) from 1990/1/2 to 2001/12/31 are regressed cross-sectionally, day by day, on put/call ratios $P/(P+C)$ (constructed from open buy volume) and control variables: the log of firm size ln(sz), the option trading volume divided by its underlying stock trading volume $\frac{option}{stock}$ (in bps), the log of the number of analysts covering the stock ln(1+A), the stock's NYSE-based book-to-market deciles "bm" and its momentum deciles "mom," past week returns $R_{-5,-1}$ (in bps), stock trading volume (millions), and its interaction with day-0 stock returns R_0. Both $\frac{option}{stock}$ and ln(1+A) have been orthogonalized to ln(sz)(cross-sectionally, day by day). T-stats are reported in square brackets.

intcpt	$\frac{P}{P+C}$	$\ln(sz) \times \frac{P}{P+C}$	$\frac{option}{stock} \times \frac{P}{P+C}$	ln(1+A) $\times \frac{P}{P+C}$	$\ln(sz)$	$\frac{option}{stock}$	ln(1+A)	bm	mom	$R_{-5,-1}$	stock volume	volume $\times R_0$
Panel A: +1-day returns as dependent variable												
23.1	-51.0											
[7.71]	[-27.69]											
26.1	-45.5				-1.2	-0.06	-1.3	-0.01	0.8	-0.021	0.011	-0.18
[3.57]	[-27.83]				[-1.89]	[-0.86]	[-1.08]	[-0.03]	[2.49]	[-16.92]	[1.24]	[-0.77]
59.2	-167.5	15.6	0.6	-3.2	-5.5	-0.2	0.1	-0.1	0.8	-0.021	0.012	-0.31
[6.72]	[-14.65]	[12.13]	[2.78]	[-0.87]	[-6.55]	[-1.92]	[0.07]	[-0.33]	[2.64]	[-17.25]	[1.40]	[-1.37]
Panel B: +2-day returns as dependent variable												
12.5	-24.2											
[4.19]	[-13.67]											
2.6	-24.2				0.9	0.01	-0.1	-0.1	0.9	-0.011	-0.012	-1.76
[0.36]	[-15.40]				[1.44]	[0.12]	[-0.13]	[-0.47]	[2.93]	[-9.21]	[-1.43]	[-8.72]
21.4	-93.0	8.5	0.2	-3.8	-1.4	-0.1	1.1	-0.2	0.9	-0.011	-0.010	-1.76
[2.66]	[-7.91]	[6.40]	[0.88]	[-1.01]	[-1.86]	[-0.64]	[0.70]	[-0.67]	[2.89]	[-9.32]	[-1.21]	[-8.76]
Panel C: +5-day returns as dependent variable												
7.9	-8.9											
[2.67]	[-5.19]											
-2.2	-8.9				0.8	-0.2	1.3	-0.1	0.8	-0.002	-0.009	0.22
[-0.31]	[-5.81]				[1.28]	[-2.96]	[1.12]	[-0.28]	[2.73]	[-1.61]	[-1.06]	[1.19]
3.6	-29.7	2.6	-0.3	-1.2	0.1	-0.1	1.4	-0.1	0.8	-0.002	-0.008	0.15
[0.47]	[-2.92]	[2.23]	[-1.42]	[-0.33]	[0.10]	[-1.37]	[0.87]	[-0.28]	[2.73]	[-1.60]	[-1.04]	[0.80]
Panel D: +8-day returns as dependent variable												
6.6	-3.2											
[2.23]	[-1.82]											
-2.0	-4.5				0.6	-0.1	1.3	0.2	0.7	0.002	-0.006	-0.06
[-0.28]	[-2.84]				[0.93]	[-1.48]	[1.15]	[0.76]	[2.45]	[2.04]	[-0.71]	[-0.28]
2.8	-16.6	1.5	-0.1	-5.7	-0.0	-0.1	2.4	0.1	0.7	0.002	-0.005	-0.07
[0.33]	[-1.47]	[1.18]	[-0.69]	[-1.59]	[-0.00]	[-1.32]	[1.49]	[0.53]	[2.41]	[2.03]	[-0.65]	[-0.35]

control variables. The daily cross-sections consist of underlying stocks that have options with at least 50 contracts of open buy volume. The dependent variable is the $+n$-day stock return, and the explanatory variable is the put/(put+call) ratio computed from open buy volume. The control variables are the log of firm size, the ratio of option volume to underlying stock volume, the log of 1 plus the number of analysts covering the stock (n=0 if no analyst coverage), the NYSE-based book-to-market decile, the momentum decile, the past five-day stock return $R_{-5,-1}$, the day-0 stock trading volume, and the day-0 stock trading volume interacted with the day-0 stock return.[19] We use monthly data on firm size, analyst coverage, book-to-market and momentum deciles, and daily data on stock trading volume. Both firm size and analyst coverage are recorded at the end of the previous month, book-to-market deciles are lagged 6 months, and momentum deciles are formed based on prior six-month returns skipping the most recent month. The results are presented in Table 7. The reported regression coefficients are time-series averages of the cross-sectional regression coefficients, and t-stats obtained from Fama and MacBeth (1973) standard errors are given in square brackets.

The first row of Panel A in Table 7 examines the predictability of the put/call ratio $P/(P+C)$ in the absence of the control variables. As reported, the next day return decreases by an average of 51 basis point when a stock moves from $P/(P+C) = 0$ — one with all call options traded to $P/(P+C) = 1$ — one with all put options traded. This is consistent with our earlier finding that (1) the next day expected return of the low-PC portfolio is about 40 basis points higher than the high-PC portfolio, and (2) the average $P/(P+C)$ is 0.1% for the low-PC portfolio and 79.7% for the high-PC portfolio.

The second row of Panel A reports the predictability of the put/call ratio in the presence of the control variables. Among the 8 control variables, the effect of short-term reversal (see, for example, Lo and MacKinlay (1990)) is the most significant.[20] To control for potential informed trading in the stock market, we use the day-0 stock trading volume and its interaction with the day-0 stock return. Neither of the coefficients are significant, and adding the control variables does not affect our results in any significant way. One should, however, bear in mind that this trading information from the stock market is inferior to what we have for the option market. Consequently, we do not draw any strong conclusion about informed trading in the underlying stock market.

In the third row of Panel A, we add interaction terms in the cross-sectional regressions to investigate further if the information transmission is higher or lower conditional on firm size, option trading activity relative to underlying stock trading activity, and analyst coverage. For firm size, we obtain the same result as before: the larger the size, the lower the predictability from the $P/(P+C)$ variable. The relative activity variable, however, runs counter to one's intuition. Specifically, our result suggests that the more active the option market is relative to the underlying stock market, the lower the level of information transmission from option trading to future stock prices. This finding, however, to some extent

[19] Given that trading volume and analyst coverage are both highly correlated with size, we orthogonalize these two variables with respect to the size variable before putting them in the cross-sectional regression. Although this has no effect on the basic regression, it might affect our interpretation of the interaction terms.

[20] In fact, in unreported results we found that the short-term reversal has the largest effect on the predictability coefficient of the put/call ratio.

relieves our concern that the predictability of the put/call ratios comes from a mechanical price pressure on the underlying stock market due to increased purchases of options (e.g., positive price pressure from buying calls and negative price pressure from selling puts).

In Panels B, C and D, we repeat the same cross-sectional regressions for the +2, +5, and +8-day returns. Consistent with our earlier results, the effect becomes weaker in magnitude and statistical significance as we move further into the future. Similar to the findings reported in Panel A, adding the control variables does not affect our results in any significant way.

3.3 Information in other volume types and aggregate volume

Up to this point our analysis has focused on open buy volume — trades initiated by buyers to open new option positions — since it seems to be the most natural place to look for informed trading. In this section, we examine the information content in open sell, close buy and close sell volume. Our approach is identical to that in Section 3.1. We aggregate each type of volume by all investor classes, apply the same filtering rule (i.e., at least 50 contracts), and sort the cross-sectional sample by put/call ratio. The results are presented in Table 8.

The open sell (OS) volume is initiated by sellers to open new positions. Assuming speculation as the only motive for option trading, one would expect the information content in the OS volume to be the mirror image of that in the open buy (OB) volume. For example, anticipating the price of a stock to fall, one could either buy a put or sell a call. This assumption, however, is not supported by the data. From Table 8, we see that there is predictability in the OS volume for future stock prices in the direction that is expected — the stocks with more fresh call options written later underperform those with more fresh put options written. The magnitude and statistical significance of the OS volume predictability, however, are markedly weaker than for the open buy (OB) volume. The returns leading up to portfolio formation exhibit the same contrarian pattern: the stocks with more fresh call options written have been outperforming those with more fresh puts written. Compared with the OB case, however, the magnitude of this contrarian pattern is much larger, and unlike the OB case, the contrarian pattern increases leading up to and including the portfolio formation day. Although it is difficult to pinpoint the motivations behind the OS volume using our dataset, our evidence suggests that there is less informed trading in the OS volume.

The close buy volume is initiated by buyers to close existing short option positions, while the close sell volume is initiated by sellers to close existing long option positions. Compared to the open volume, the information content in the close volume is less transparent since it is more likely to involve investors' original motivation for opening the existing positions and their attitudes towards past gains and losses. From Table 8, we see that there is some predictability in the expected direction from these volumes, but the magnitude and statistical significance are much weaker than for the OB volume.

Finally, we address the question of predictability from publicly available information. The OB, OS, CB, and CS volumes are not publicly observable. The daily put and call volumes aggregated across these four volume types, however, can be easily obtained from the OCC website (the Option Clearing Corporation) which further breaks down daily trading volume by firm proprietary traders, public customers, and full-service brokers. To examine

Table 8: **Returns to buying low-PC and selling high-PC portfolios, by volume type**

Portfolios are formed by selling stocks in the top put/call quintile and buying stocks in the bottom put/call quintile. The put/call ratios are constructed from open buy (OB), open sell (OS), close buy (CB) and close sell (CS) volumes. OB is initiated by buyer to open a new option position, OS is initiated by seller to open a new position, CB is initiated by buyer to close an existing position, and CS is initiated by seller to close an existing position. The put/call ratio in "all" is calculated by aggregating all four volume categories. Daily data from 1990/1/2 to 2001/12/31 are used.

	day relative to portfolio formation															
	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
	Panel A: average daily returns (in basis points)															
OB	-12.8	-14.7	-18.6	-15.8	-3.9	37.4	39.6	21.6	12.9	12.1	8.8	6.2	2.6	4.7	2.9	4.1
OS	20.1	28.9	38.9	49.1	95.4	158.6	-7.9	-8.6	-6.4	-6.8	-3.5	-1.6	0.1	-2.6	0.3	-2.8
CB	5.6	0.6	-5.6	-14.6	-46.8	-85.6	7.0	8.7	3.5	4.5	4.2	1.4	-2.6	1.6	0.3	-0.5
CS	40.9	53.9	71.7	101.1	168.8	195.9	-5.9	-12.4	-4.5	-3.0	-1.2	-0.8	1.1	0.4	3.1	1.4
all	12.9	17.9	23.8	34.5	65.8	98.9	16.1	4.4	2.3	0.7	3.1	0.6	2.1	0.5	1.2	-0.2
	Panel B: t-stats															
OB	-8.04	-9.08	-11.46	-9.44	-2.24	19.77	23.79	13.11	8.18	7.77	5.50	3.86	1.67	2.94	1.80	2.62
OS	12.53	18.40	25.23	29.63	55.36	79.84	-5.02	-5.50	-4.04	-4.34	-2.27	-1.05	0.08	-1.67	0.17	-1.80
CB	2.88	0.33	-2.80	-7.25	-20.83	-35.45	3.59	4.61	1.85	2.35	2.24	0.71	-1.42	0.84	0.17	-0.27
CS	21.11	27.77	36.79	50.21	75.00	76.52	-2.91	-6.34	-2.32	-1.55	-0.62	-0.44	0.58	0.23	1.58	0.74
all	10.11	14.49	18.92	27.51	51.19	72.04	13.05	3.56	1.87	0.54	2.50	0.48	1.72	0.44	0.93	-0.16

On average (cross-sectional and time-series), the total put volume consists of 28.9% OB, 39% OS, 16.4% CB, and 15.7% CS, and the total call volume consists of 32.4% OB, 36% OS, 13.1% CB, and 18.5% CS.

the level of predictability from such publicly available option volume, we report in Table 8 the results when the PC ratio is constructed from "all" of the volume types aggregated together. Although there is still significant predictability from the aggregate volume, its magnitude and duration are considerably less than that for the OB volume.[21] As a robustness check, we use the trade data in the Berkeley Option Data Base to construct the actual CBOE daily trading volume for each equity option from January 2, 1987 to December 31, 1996. Applying the same analysis to this dataset, we find a similar level of predictability: the average daily returns are 13 bps, 3.8 bps, and 1.3 bps for the +1, +2, and +3 days, respectively, and the associated t-statistics are 9.96, 2.95 and 0.98.

3.4 Information in index option trading

In this section, we examine the information content of option trading on three broad market indices: the S&P 100 (OEX), S&P 500 (SPX), and Nasdaq-100 (NDX) indices. This is to investigate whether investors in the option market possess information about future price movements at the aggregate level. Although we found significant informed trading at the individual stock level, it seems less plausible that that investors would have superior information at the market level. It also runs counter to the common belief that investors use index options mostly for hedging rather than speculating.[22]

To formally investigate the information content of index option trading, we perform univariate regressions of the next-day index returns on the put/(put+call) ratio. To extract as much information as possible, we perform these regressions by option volume type and investor class. If there is informed trading in the index option market, we expect to see a significant regression coefficient that is negative for open buy and close buy volume, and positive for open sell and close sell volume. As shown in Panel A of Table 9, we do not find strong support for informed trading in the index option market.[23]

Finally, given that we did find evidence of informed trading in the equity options market, it is interesting to investigate whether the collective informed trading on individual equity options provides any information about future aggregate stock market movements. To address this question, we aggregate open buy trading volume on equity options across all stocks, and form a value-weighted put/(put+call) ratio for the aggregate market. We then use this put/(put+call) ratio to predict the next-day returns (excluding dividends) of the CRSP value-weighted and equal-weighted portfolios. The results from these univariate

[21]Under the assumptions that the investors in our sample trade only with the market makers and that the market makers do not trade among themselves, the "all" variable would also be identical to a variable constructed from the total put and call trading volume reported by the CBOE.

[22]An interesting distinction between equity and index options can be seen in the difference in investor composition reported in Table 1. In particular, we see that firm proprietary traders make up over 20% of the total volume in the option market for the S&P 500 index and the Nasdaq-100 index, while their average participation in the equity options market is less than 10%.

[23]It is interesting to mention that the conventional wisdom on Wall Street is to use the put/call ratio on index options as a contrarian rather than a momentum signal. That is, when the put/call ratio becomes high, it is supposed that the market has become too bearish and it is time to take a long position on the market. On the other hand, when the put/call ratio becomes low, the market has become too bullish and it is time to short. In Table 9, this contrarian use of the put/call ratio at the index level finds some support in our open buy volume results.

Table 9: **Univariate time-series regressions of next-day returns on put/call ratios**

The put/call ratio is put volume divided by option volume. In Panel A, index option volumes are used to form the put/call ratio, and the next-day S&P 500, S&P 100, and Nasdaq 100 index returns are regressed on their respective put/call ratios. In Panel B, all available equity option volumes are aggregated to form the put/call ratio, and the next-day returns of the CRSP value-weighted and equal-weighted portfolios are regressed on this put/call ratio. The volumes are identified by type (open buy, open sell, close buy, and close sell) and investor class (Traders, public customers from Full service, Discount service, and Others). The sign attached to each volume type indicates the expected regression relationship under the assumption of informed trading in index options or in the aggregate equity options. Returns are in basis points. Only the slope coefficients and their respective t-stats are reported. The standard errors are corrected for heteroskedasticity and autocorrelation.

	open buy (“–”)				open sell (“+”)				close buy (“–”)				close sell (“+”)			
	T	D	F	O	T	D	F	O	T	D	F	O	T	D	F	O
Panel A: using index option volume to predict																
SPX	-8.5	10.2	-1.5	1.8	2.6	-8.6	-9.2	7.6	1.5	3.9	-1.0	0.1	4.5	2.2	-1.6	9.6
t-stats	-1.13	1.08	-0.14	0.24	0.33	-1.49	-0.99	1.18	0.25	0.82	-0.14	0.01	0.74	0.33	-0.21	1.68
OEX	7.3	43.7	64.5	-5.6	16.1	-10.1	-5.3	-12.5	11.4	-1.6	-0.1	-6.2	-1.3	5.0	41.5	3.5
t-stats	0.90	3.12	3.60	-0.46	1.69	-0.95	-0.35	-1.22	1.36	-0.17	-0.01	-0.58	-0.16	0.41	2.93	0.29
NDX	-3.2	46.5	12.1	36.0	2.0	-3.6	-7.9	-14.2	-0.3	0.9	19.2	16.4	-9.4	-5.8	-3.9	1.2
t-stats	-0.26	3.11	0.69	3.09	0.16	-0.34	-0.57	-1.16	-0.03	0.08	1.42	1.49	-0.81	-0.47	-0.27	0.11
Panel B: using equity option volume to predict																
VW	-1.7	78.0	-22.2	-8.4	-8.1	-44.5	-33.8	2.5	1.2	41.7	18.7	10.0	7.2	-2.0	1.4	9.1
t-stats	-0.14	3.10	-0.74	-0.48	-0.67	-1.86	-1.11	0.16	0.12	2.29	0.76	0.70	0.69	-0.12	0.07	0.51
EW	-22.4	59.1	-100.5	-51.2	-27.6	-93.9	-85.6	-7.5	-9.5	41.2	14.7	8.1	-13.7	-78.4	-87.9	-56.4
t-stats	-1.99	2.54	-3.57	-3.36	-2.59	-4.52	-3.24	-0.51	-1.14	2.80	0.66	0.72	-1.53	-5.60	-5.43	-3.61

regressions are reported in Panel B of Table 9. Similar to our findings using the index option volume directly, the results are inconclusive.

4 Conclusion

In this paper, we present strong evidence that equity option volume possesses information for future changes in underlying stock prices. Taking advantage of a unique dataset from the CBOE that provides detailed classification of option trading volume, we constructed put/call ratios using option volume that is initiated by buyers to open new positions. Treating these put/call ratios as an indicator left behind by option investors, we investigated their predictability for future stock returns. We found that buying stocks with low put/call ratios and selling stocks with high put/call ratios generates an expected return of 40 basis points per day with a t-stat of 24, and 1% per week with a t-stat of 12. Moreover, this result is stronger in magnitude for small stocks, suggesting that the option volume is more informative when the underlying stock has less efficient information flow.

Our results, obtained from daily cross-sectional analysis over a 12-year period, stayed impressively consistent at the annual level, and were not affected at all by the exclusion of earnings announcement windows. This indicates that to some extent the informed option trading we have captured in this paper is a regular occurrence. This contrasts and adds to the existing literature that finds little evidence that option trading volume is informative about future stock prices except during time periods leading up to important firm specific news. Moreover, our results are robust to controlling for a number of factors, including size, book-to-market, short-term reversal, intermediate-term momentum, the ratio of option volume to stock volume, analyst coverage, and the day-0 stock trading volume.

Our findings naturally lead one to ask: What drives the observed informed option trading? Could it be insider information? Or is it simply legitimate information about firm specific news? Although these questions are beyond the scope of our paper, our analysis does shed light on the type of investors behind the informed option trading. We found that the option volume from customers of full service brokers provides the strongest predictability, while the volume from firm proprietary traders is not informative at all about future stock prices. We caution, however, that this does not imply that firm proprietary traders are less informed. It may only indicate that they trade in the exchange-traded option market primarily for non-informational reasons. Moreover, our analysis showed that while public customers on average trade in the option market as contrarians – buying fresh new puts on stocks that have done well and buying fresh new calls on stocks that have done poorly, the firm proprietary traders on average exhibit the opposite behavior – buying fresh new puts after stock prices fall and buying fresh new calls after stock prices increase. These results, while interesting in their own right, could potentially be useful for theoretical development on why people trade options.

We have also identified an important distinction between index option trading and equity option trading. While we found a significant amount of information trading in the equity option market, we found none in the index option market. This result could potentially be interesting for theoretical modeling or empirical tests on information asymmetry.

Finally, it should be noted that since our empirical exercise is limited to investigating the information content of option volume for future stock prices, there remains a great deal to be explored in both the option and stock markets. For instance, one important question not addressed in this paper is: Do the investors behind the informed option trading volume actually make abnormally large profits in the option market? The question speaks directly to the efficiency of the option market. More generally, while there has been a long history in the microstructure literature of investigating information linkage across markets [Easley, O'Hara, and Srinivas (1998) and references therein], low-frequency studies at the asset pricing level have been relatively few.[24] Our paper is one attempt to address the important topic of the presence of information in one market for another. As more data become available, we expect more studies along these lines. For example, recently, the informational role of credit derivative swaps (CDS) has been actively discussed. It would be quite interesting to examine the informational linkage between the CDS market, the corporate bond market, and the stock market.

[24]See also Hong, Torous, and Valkanov (2002) and Ofek, Richardson, and Whitelaw (2002).

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