The Information in Option Volume for Stock Prices

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Abstract

We find strong evidence of information transmission from the options market to underlying stock prices. Taking advantage of a unique dataset from the Chicago Board Options Exchange, we construct put to call volume ratios for underlying stocks, using only 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 that the options market may be a more important avenue for information transmission for 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 options 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 options market, we do not find any evidence of informed trading in the index options 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 of derivatives being 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 incorporated into the financial markets through trading in their derivatives. The view that information about the underlying stock price might arrive first in the options 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 options 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 options 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 options volume predicts underlying stock prices. Indeed, Cao, Chen, and Griffin (2002) find that during "normal" times, stock volume but not option volume is informative about next day stock returns. This is consistent with the findings of Chan, Chung, and Fong (2002), who conclude that option volume does not lead stock prices. Although Easley, O'Hara, and Srinivas (1998) do report that signed option volume contains information for movement in the underlying stock prices, their significant findings are concentrated in the contemporaneous relationship between option volume and stock returns.[3]

We contribute to the existing literature by providing clear 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 options volume are significant predictors

[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 early that month. The option volume uptick occurred days before the release of a government study by JAMA 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]In addition, related papers on the information linkage between the option and stock markets includes theoretical development by Grossman (1988), Back (1993), Biais and Hillion (1994), Brennan and Cao (1996), John, 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.

of cross-sectional stock returns for at least a week into the future. Our differing conclusion can be attributed to three important features that set our approach apart from the existing empirical studies.

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 by 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 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 differing 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, while many of the related papers have a microstructure focus and use intraday data to examine information transmission at intervals such as 5 minutes, our paper takes an asset pricing perspective and examines predictability over daily and weekly intervals.

In addition, another unique feature of our work is that 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 options market.

Our main conclusion on informed trading in the options 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 options 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 look for its predictability for 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 weekly rebalanced 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 an average bi-weekly return of only 1.1%.

It is important to note 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, both positive and negative, about the underlying stock arrives in the option market first and then gradually diffuses into the underlying stock prices. Although identifying the nature of such information transmission 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. Moreover, our analysis shows that while the three groups of public customers act as contrarians in the options 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 some well-established cross-sectional relation such as size, book-to-market, momentum, 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 that information flow is more efficient in larger firms.[4] 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.[5] 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 information transmission from option volume.

While we (and to a certain extent the options market makers) are able to see the option volume broken down into our four categories, 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

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

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

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 on the equity options 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 equal-weighted index returns. In short, while there is clear informational trading in the equity options market, the trading activity in the index options 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 further broken down 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 position, and "close sells" which are initiated by a seller to close an existing 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.[6] Second, unlike the previous literature, we know whether the initiator of observed volume is opening a new options 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).[7] For example, clients of E-Trade are labeled as D, while clients of Merrill Lynch

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

[7] 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

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

Daily data from 1990/1/2 to 2001/12/31 except otherwise noted. The cross-section of equity options is sorted by the underlying stock size into small, medium, and large, 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

are labeled as F. This classification of trading volume by investor type could potentially shed some light on the heterogeneity that exists in the options 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 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 options market, the trading volume for call options is on average much higher than that for put options, and this is true across open buy, open sell, close buy and close sell. 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.[8] 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 options 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 the SPX and NDX markets than they do in the equity options market.

2.2 The merged dataset

Focusing first on the equity options, which are the more important component of our analysis, 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 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 returns and trading volumes of the underlying stocks. On any given

designated by the CBOE analyst as originating from discount or full service customers.

[8]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.

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 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 options market.

The second panel in Table 2 summarizes the most important variable of 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 consist with our earlier observation that in the equity options 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 options 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 the expansion of the equity options 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: **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

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 the one 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.[9] Details of the merged open buy data are provided in Section 2.2 and Table 2.

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 average portfolio returns after portfolio formation, we see that stocks with more open buy put trading do more poorly than stocks with 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 is 10.9 basis points for the CRSP equal-weighted portfolio, and 4.2 basis points for the CRSP value-weighted portfolio. Using

[9]We use put/(put+call) instead of the more widely used measure of put/call so that the variable remains finite in the case of zero open buy call volume. 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 ±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

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 finding is consistent with the view that there is positive and negative information about the underlying stock arriving in the option market first and then gradually diffusing into the underlying stock prices.

We next examine the expected return to a hedge portfolio that is formed by buying the low-PC portfolio and selling the high-PC portfolio.[10] 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.[11] 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 the portfolio formation, although the magnitude of the associated daily returns tapers off after 5 days. If instead of 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 further reducing the portfolio formation to once every 10 business days, the average bi-weekly return to buying low-PC and selling high-PC is only 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, indicating a contrarian trading strategy — buying puts on stocks that have done well and calls on stocks that have done poorly — on the part of the 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 the +1 day, 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 result when we move on to robustness checks in the next section.

Finally, Table 4 reports additional information on some basic characteristics of the 5 PC-ranked portfolios. As expected, the high-PC (i.e., PC5) portfolio has the highest put/(put+call) ratio while the low-PC (i.e., PC1) portfolio has the lowest put/(put+call) ratio. The "option/stock" 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 on average 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

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

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

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.

	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

use these cross-sectional measures as control variables in cross-sectional regressions to see whether they have any effect on the results.

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 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.

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

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 options 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 before the options market closes. It is possible that such information is, in fact, reflected simultaneously in both the options market and in stock prices (in the aftermarket) on the portfolio formation date, but that our methodology makes it appear that the information was brought first to the options market on the portfolio formation date and shows up in the stock prices only later on the next trading day.[12] 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 options 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, in an effort to eliminate market disruptions that were occurring when news announcements, particularly earnings reports, were made when the options market was open and the underlying stock market was closed.[13] 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 level of information transmission 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

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

[13] 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.

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 partly 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 50 open buy contracts on an underlying stock to retain it for a particular trade date) to each subset,[14] 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 options market participants are informed. For example, it is possible that firm proprietary traders possess superior information about the underlying stocks but that it is not revealed in their

[14] 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.

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

aggregate open buy volume, because they use the exchange-traded options market primarily for hedging purposes.

There is 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, somewhat in the spirit of 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.[15] 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, momentum, trading volume, or analyst coverage, we perform daily cross-sectional regressions using these as 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, and the momentum decile.[16] We use monthly data on firm size, analyst coverage, book-to-market and momentum deciles, and daily data on 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.

As reported in Panel A of Table 7, the next day return decreases by an average of 51 basis point when a stock moves from one with all call options traded to one with all put options traded. This is consistent with our earlier finding that the next day expected return of the low-PC portfolio is about 40 basis points higher than the high-PC portfolio, and the average $P/(P+C)$ is 0.1% for the low-PC portfolio, and 79.7% for the high-PC portfolio. Adding control variables does not affect this result in any significant way.

We also add interaction terms in the cross-sectional regressions to investigate further

[15] 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.

[16] 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.

Table 7: **Daily cross-sectional regressions of future 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 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 $\frac{option}{stock}$, 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). Both $\frac{option}{stock}$ and ln(1+A) have been orthogonalized to $\ln(sz)$ (cross-sectionally, day by day) before being used as the cross-sectional indepenent variables. 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
Panel A: +1-day returns as dependent variable									
23.1	-51.0								
[7.71]	[-27.69]								
25.3	-49.3				-1.1	-0.1	-1.0	-0.1	1.0
[3.49]	[-29.09]				[-1.95]	[-1.66]	[-0.82]	[-0.27]	[2.87]
57.8	-173.3	15.8	0.8	-3.4	-5.3	-0.3	0.5	-0.2	1.0
[6.67]	[-14.95]	[12.13]	[3.88]	[-0.88]	[-6.95]	[-3.11]	[0.27]	[-0.61]	[3.05]
Panel B: +2-day returns as dependent variable									
12.5	-24.2								
[4.19]	[-13.67]								
2.7	-25.0				0.5	0.04	-0.1	-0.1	1.1
[0.39]	[-15.39]				[0.86]	[0.59]	[-0.08]	[-0.42]	[3.33]
23.1	-96.2	8.7	0.3	-3.0	-2.0	-0.1	1.0	-0.2	1.1
[2.87]	[-7.79]	[6.27]	[1.38]	[-0.78]	[-2.82]	[-0.59]	[0.62]	[-0.68]	[3.33]
Panel C: +5-day returns as dependent variable									
7.9	-8.9								
[2.67]	[-5.19]								
-1.1	-9.1				0.5	-0.2	1.0	-0.1	0.9
[-0.16]	[-5.74]				[0.98]	[-2.68]	[0.82]	[-0.19]	[2.69]
5.6	-32.1	2.8	-0.2	-0.7	-0.3	-0.1	1.1	-0.1	0.9
[0.75]	[-3.09]	[2.41]	[-1.13]	[-0.19]	[-0.49]	[-1.45]	[0.67]	[-0.21]	[2.68]
Panel D: +8-day returns as dependent variable									
6.6	-3.2								
[2.23]	[-1.82]								
-0.5	-4.1				0.3	-0.1	1.6	0.1	0.8
[-0.08]	[-2.53]				[0.60]	[-1.13]	[1.38]	[0.44]	[2.37]
4.8	-15.5	1.4	-0.1	-5.9	-0.3	-0.1	2.5	0.1	0.7
[0.54]	[-1.30]	[1.05]	[-0.52]	[-1.64]	[-0.37]	[-1.23]	[1.51]	[0.20]	[2.30]

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 relieves our concern that the predictability of 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.

3.3 Information in open sell 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

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.

significance are much weaker than for the OB volume.

Finally, we address the question of predictability from publicly available information. Specifically, the OB, OS, CB, and CS volumes are not publicly observable. To examine the level of predictability from option volume using only publicly available information, we report in Table 8 results using aggregate volume, which is the summation of the OB, OS, CB, and CS volumes. Assuming that the investors in our sample trade only with the market makers and that the market makers do not trade among themselves, our aggregate volume is the total put and call trading volume reported by the CBOE.[17] From Table 8, we see that although there is still significant predictability from the aggregate volume, its magnitude and duration are less than that for the OB volume. 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 11 bps, 4 bps, and 2 bps for the +1, +2, and +3 days, respectively, and the associated t-stats are of similar magnitudes.

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.[18]

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 sell volume, and positive for open sell and close buy volume. In Panel A of Table 9, we do not see any evidence of such results.

Finally, given that we did find evidence of informed trading in the equity options market, it is interesting to know whether the collective informed trading on individual equity options provides any information about future aggregate stock market movements. To investigate this question, we aggregate 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 regressions

[17]It should also be noted that our aggregate volume measure is easily obtained from the OCC website which breaks down daily trading volume by firm proprietary traders, public customers, and market makers.

[18]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%.

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

are reported in Panel B of Table 9. When predicting the value-weighted market returns, the only positive result comes from close buy volume initiated by customers of discount brokers. For the equal-weighted index returns, the results are more encouraging, although they are mixed across volume type and investor class.

4 Conclusion

In this paper, we have documented strong evidence of information transmission from equity options volume to future stock prices. Taking advantage of a unique dataset from the CBOE that provides detailed classification of option trading volume, we have 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 options investors, we looked for 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, indicating stronger cross-market information transmission for stocks with 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. To some extent, this indicates that the information transmission we have captured in this paper is something of a regular occurrence. This contrasts and adds to the existing literature that finds options trading volume to be uninformative about future stock prices except for time periods leading up to important firm specific news [Cao, Chen, and Griffin (2002)]. Moreover, our results are robust to controlling for a number of factors, including size, book-to-market, momentum, the ratio of option volume to stock volume, and analyst coverage.

Our results naturally lead one to ask: What drives the observed information transmission? Could it be insider information? Or is it simply because investors with legitimate superior information about firm specific news tend to trade in the options market? 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 options market primarily for non-informational reasons. Moreover, our analysis showed that while public customers on average trade in the options 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 when stock prices fall and buying fresh new calls when stock prices increases. Given that derivatives thrive on heterogeneity, 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 options market, we found none in the index options market. This result could potentially be interesting for theoretical modeling or empirical tests on information asymmetry.

Finally, while there has been a long history in the microstructure literature of investigating information transmission across markets [Easley, O'Hara, and Srinivas (1998) and references therein], low-frequency studies at the asset pricing level have been relatively few.[19] Our paper is one attempt to address the important topic of cross-market information transmission. 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.

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

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