The Economics of Option Trading*

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Abstract

An option provides a bundle of economic characteristics, including leverage, exposure to the underlying asset, exposure to a particular dynamic trading strategy, and exposure to volatility and jumps. The wide variety of traded options permits investors to choose particular economic characteristics. We group exchange-traded equity options into delta- and maturity-based buckets, which provide differential exposure to these economic characteristics. We examine the determinants of volume, signed volume, open interest, and gamma volume for these buckets. Option activity is concentrated in out-of-the-money and at-the-money options. Equity option activity is affected strongly by volume in the underlying asset, earnings announcements and dividend payments. Earnings announcements in particular generate substantial increases in volume in near-term at-the-money and out-of-the-money options, no increase in open interest, and small additional negative gamma exposure for market-makers. Examination around earnings announcements of option trading by investor categories finds that small customers are likely to be option buyers, with large customers and firms supplying written options.

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1 Introduction

Option pricing has been well-studied since Black and Scholes (1973), but there has been less attention paid to understanding how traders actually use options. This paper uses data on signed daily option volume, the so-called open/close data, to examine the questions of what generates option trading volume and which kinds of options are traded in response to economic events. In this paper we consider only individual equity options, since index options may be traded for different reasons.

As emphasized out by Liu and Pan (2003), an option is a financial instrument that provides a bundle of conceptually distinct economic characteristics. There are not widely-accepted theories of why investors trade options, but there are at least three considerations relevant for any explanation. First is that options represent a leveraged position in the underlying asset. For some investors, leverage obtained by buying or selling an option could possibly be less expensive than leverage obtained in other ways. The second is that owning an option generates returns that are equivalent to a dynamic trading strategy in the underlying stock and borrowing. Depending on the moneyness of the option, the amount of trading in the underlying stock required to replicate the option can be large or small. The greek measure gamma measure the amount of such trading. Generally, the option's sensitivity to changes in volatility, vega, is large when gamma is large and vice versa. Finally, the option provides exposure to jumps in the stock price. A discrete change in the stock price is the percentage amount by which the value of the position changes when the stock price jumps discretely. (Gamma measures the effect of small changes.) We call the sensitivity to jumps kappa. A natural way to construct the buckets is to do so based on differences in these economic characteristics of the option. We discuss this in Section 2. This also provides a basis for discussing the results.

Because there is a wide array of options available with different strike prices and times to expiration, an option trader can effectively choose the particular economic characteristics of interest. One could imagine that options are valued because they implicitly provide leverage, or valued because they provide an implicit trading strategy (or a blend of the two). We find that, unconditionally, trading volume is most concentrated in buckets where options have the greatest gamma and jump risk. It is also concentrated in these options when investors trade options around earnings announcements.

In practice, investors can also trade spread positions, simultaneously buying and selling, in order to further isolate a particular characteristic. We observe only data on a series by series basis (a series is defined as a put or call with a particular ticker, expiration, and strike). We therefore have no information about the particular strategies option traders are undertaking.[1]

One issue we study is the extent to which market-makers accommodate option trading strategies. Market-makers buy and sell options to meet the de-

[1] The clearinghouse will have complete information about option positions by trader, so the information is potentially available. Papers that do have such information about strategies include Chaput and Ederington (2003, 2005b,a, 2008) and Fahlenbrach and Sandås (2010).

mands of investors. It is possible that market makers simply provide immediacy, and that investors serve as counterparties to each other over the course of a day, with market-makers temporarily holding inventory. Alternatively, market makers could end up satisfying a net investor demand for options, in which case they would transform the option positions into shares by offseting the risk of the positions they acquire by trading the stock, a procedure known as delta-hedging.[2] Intuitively, to the extent that option trading simply reflects differences of opinion, the transformative technology of market-makers is needed less than if option investors generally are trying to implement a particular strategy.

We follow Lakonishok et al. (2007) and each day place each option into one of nine categories based on the option moneyness and time to maturity. Unlike Lakonishok et al. (2007), our buckets are based on delta rather than strike price. We then run pooled cross-section time-series regressions explaining volume for these categories as a function of explanatory variables such as stock volume, implied volatility (lagged), proximity to earnings announcements, proximity to expiration, and other explanatory variables. Our time period allows us to study the effect of the financial crisis, so we include as explanatory variables the LIBOR-OIS spread and dummies for the periods around the Bear and Lehman failures and the short-sale restrictions in September and October 2008.

By placing options into different buckets, we allow for differential trading based on different economic characteristics of the options. Deep out-of-the-money options, for example, are inexpensive, highly leveraged, and sensitive to jumps in the stock price. In-the-money options, by contrast are expensive, less leveraged, and less sensitive (as a percentage of the option price) to jumps in the stock. Although deep in-the-money options are less leveraged than out-of-the-money options, they provide “pure” leverage in that the exposure to the stock is almost constant. For a given degree of moneyness, all of these characteristics vary with maturity.

Many papers have examined research questions related to the topic in this paper. Most closely related are papers that directly examine determinants of option volume, including Anthony (1988), Lakonishok et al. (2007) and Roll et al. (2010). Related papers consider the use of options to implement particular strategies, such as speculating on earnings. See, for example, Patell and Wolfson (1979, 1981), Ni et al. (2008), Chang et al. (2010). Second, a set of papers asks whether option trading affects the pricing of options. These include Bollen and Whaley (2004) and Gârleanu et al. (2009). Finally there are papers that consider the economic implications of options trading, including questions such as whether information about the stock is expressed differentially in stock and options markets and how option trading affects the manner in which information is expressed in the stock market (Jennings and Starks, 1986).

The paper most closely related to ours is Lakonishok et al. (2007), who ex-

[2] McDonald (2006, Chapter 13) provides a detailed discussion of delta-hedging. Although we cannot observe market makers delta-hedging, it is widely believed in the industry that market makers do delta-hedge and it is natural that an accommodating counterparty would try to hedge risk.

amine option volume. Almost all of their empirical work uses delta-weighted volume, whereas we use unweighted volume or gamma volume. Delta-weighting measures the "share-equivalent" of an option position, assigning the most weight to in-the-money options (which have a delta large in absolute value) and little weight to out-of-the-money options (which have a delta small in absolute value). Thus, their explanatory equations will give little weight to out-of-the-money options. Their approach views options as a stock substitue, whereas we are interested in studying options as options. Also related is a series of papers, Chaput and Ederington (2003, 2005b,a, 2008), which examine trading on Eurodollar futures. Their data differs from ours in that they can identify specific trading strategies. Also, eurodollar futures are largely used by corporations and banks hedging interest rate risk rather than individual investors.

Other recent papers examing options include Fahlenbrach and Sandås (2010), who find using FTSE-100 data that trading in volatility-sensitive option strategies predicts future volatility. Ni et al. (2008) use vega-weighted volume to also examine trading in volatility-sensitive options positions. Roll et al. (2010) use aggregate data to study the time series behavior of U.S. option volume aggregated by the underlying stock, but do not examine differential responses of option buckets. Roll et al. (2009) examine the characteristics of firms on which options are heavily traded, finding, for example, that firms on which options are actively traded have a greater Tobin's Q.

2 Option Characteristics

Standard option pricing theory (Black and Scholes, 1973) implies that options are redundant securities. However, in practice there are a number of reasons why investors might prefer to trade either the stock or an option. In particular, investors face transaction costs and options span risks (such as volatility) that are not otherwise tradeable. Thus, there are multiple possible motives for option trading:

- Options expire. An investor planning to own the stock for a long holding period may thus prefer the stock, to minimize transaction costs.

- The stock receives dividends and carries voting rights while the option does not. The investor may view receipt of dividends as either an advantage or a disadvantage, but the point is that the option and stock differ in this respect.

- The option is equivalent to a dynamically-adjusted position in the stock. Delta measures the "share-equivalent" of the stock (the number of shares with equivalent price sensitivity to a stock price change) and gamma measures the change in delta with respect to the stock price. As the stock price changes, the delta of the option changes, providing the option investor a particular dynamic trading strategy. For an investor seeking this particular trading strategy, the option is likely to be less costly than trading the stock to mimic the option. One possible explanation for investors to seek the payoff pattern inherent in an option is differential risk aversion, e.g. see Leland (1980) and Brennan and Solanki (1981). This literature shows that investors will demand convex payoffs (e.g., buying a call or put) if their absolute risk aversion increases more rapidly than that of the aggregate investor.

- The option price is a convex function of the stock price, hence changes in the stock's volatility affect the option price. The option price thus depends on volatility, and the option provides a way to trade volatility.

- The option is a leveraged position in the stock. If the implicit interest cost in an option differs from the explicit interest cost of borrowing to buy the stock (or shorting the stock and lending), either option or stock positions may be preferred.

We first examine the sensitivity of options to particular risks, such as changes in the price of the underlying asset (delta and gamma) and exposure to jumps — discrete moves in the stock price. With the Black-Scholes formula, for a given stock price and time to maturity, vega (exposure to volatility) and gamma are proportional, so it is not possible to disentangle demand stemming from desired exposure to volatility to demand stemming from the desired exposure to the implicit dynamic trading strategy in an option.

Table 1 summarizes delta, gamma, and jump risk of options for a variety of strike prices and times to maturity. Delta and gamma are standard option risk measures. We are not aware of a standard measure of jump risk, which Gârleanu et al. (2009) refer to as kappa. Intuitively, one measure of jump risk would assess the extent to which the option return differs from the levered stock return in the event of a large move. To assess this, we assume that there is an equal probability of an up or down move in the stock price, and compare the resulting average change in the option price to the average change in the stock price, which is zero since the jump is symmetric. Letting α denote the percentage change in the stock price, the jump risk measure is

$$\kappa = 0.5\left[C(S(1+\alpha),t) + C\left(\frac{S}{1+\frac{\alpha}{1-\alpha}},t\right)\right] - C(S,t) \tag{1}$$

This expression assumes that the expected jump is zero. In our illustrations of option price risk we use the Merton (1976) option pricing formula which permits jumps (but not risk premia associated with jumps). We do not attempt to calibrate the option pricing model. The goal of the calculations is to have a sense of the curvature of the option price function rather than to price options with precision.

By the measure of equation (1), a sufficiently deep in-the-money or out-of-the-money option or would have no jump risk, since the average option price after the jump is the same as before the jump. (The definition of "sufficiently" in this statement is that the jump does not significantly change the option's

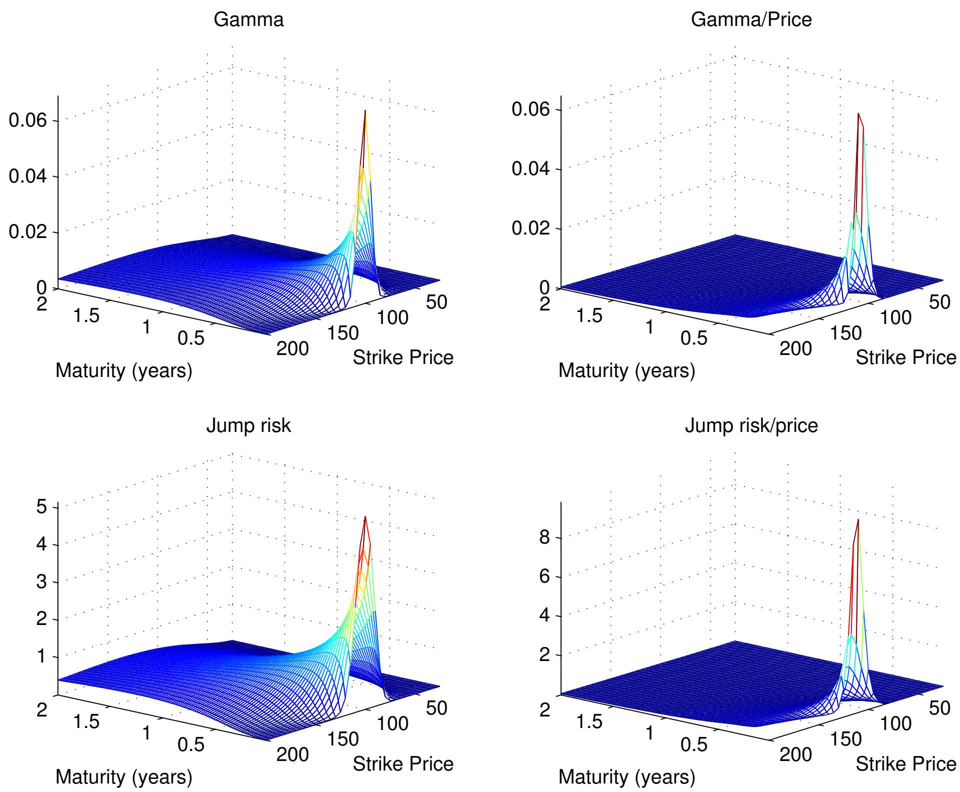


Figure 1: Surface plots for gamma, gamma/option price, jump risk, and jump risk/divided by option price, as a function of time to expiration and strike price; assumes $\sigma = 0.40$, $r = 0.06$, and $\delta = 0$.

delta.) A mildly out-of-the-money or in-the-money option by contrast could have substantial jump risk because the jump would permit it to come back into or og the money.

Table 1 and Figure 1 illustrate several points. First, for very short-term options, gamma and jump risk take on their largest values and are relatively symmetric around the stock price. As time to maturity increases, both measures decline but become relatively more important for out-of-the-money options. The rightmost panels in Table 1 and Figure 1 display gamma and jump risk divided by the option price. The conclusion remains that both gamma and jump risk can be most efficiently acquired by purchasing short-term options that are near the money and out-of-the-money. As maturity increases, out-of-the-money options exhibit relatively more gamma and jump risk but substantially less than near-term options. These qualitative conclusions are unchanged when we change α, the jump magnitude in equation (1). For example, if we increase α from 15% to 30%, jump risk triples and jump risk relative to price increases as much as

Table 1: Call option characteristics as a function of strike price and time to expiration, computed using the Merton (1976) jump option pricing formula. Assumes that $S = \$100$, $\sigma = 0.40$, $r = 0.06$, $\delta = 0$, $\lambda = 1.0$ (jump intensity), $\alpha_J = 0$ (average jump), and $\sigma_J = 0.30$ (jump standard deviation). A 15% jump upwards is assumed in computing jump risk.

Strike — Time to Expiration (years) — Time to Expiration (years)

Delta

Strike	0.0400	0.2500	0.7500	1.5000
60	0.9986	0.9853	0.9379	0.9046
70	0.9962	0.9544	0.8815	0.8538
80	0.9905	0.8783	0.8064	0.7967
90	0.9084	0.7446	0.7188	0.7363
100	0.5294	0.5740	0.6263	0.6753
110	0.1433	0.4051	0.5355	0.6155
120	0.0263	0.2673	0.4512	0.5585
130	0.0104	0.1695	0.3761	0.5051
140	0.0071	0.1065	0.3111	0.4556
150	0.0050	0.0680	0.2562	0.4104

	Gamma				Gamma/Price			
Strike	0.0400	0.2500	0.7500	1.5000	0.0400	0.2500	0.7500	1.5000
60	0.0001	0.0010	0.0027	0.0028	0.0000	0.0000	0.0001	0.0001
70	0.0002	0.0035	0.0047	0.0038	0.0000	0.0001	0.0001	0.0001
80	0.0012	0.0085	0.0066	0.0047	0.0001	0.0004	0.0002	0.0001
90	0.0187	0.0142	0.0082	0.0054	0.0017	0.0009	0.0003	0.0002
100	0.0483	0.0176	0.0093	0.0061	0.0132	0.0017	0.0005	0.0002
110	0.0261	0.0172	0.0097	0.0064	0.0314	0.0027	0.0007	0.0003
120	0.0046	0.0142	0.0096	0.0067	0.0172	0.0037	0.0008	0.0003
130	0.0007	0.0103	0.0091	0.0067	0.0042	0.0044	0.0010	0.0004
140	0.0003	0.0069	0.0084	0.0066	0.0032	0.0047	0.0012	0.0004
150	0.0003	0.0044	0.0075	0.0065	0.0037	0.0046	0.0013	0.0005

	Jump risk				Jump Risk/Price			
Strike	0.0400	0.2500	0.7500	1.5000	0.0400	0.2500	0.7500	1.5000
60	0.0120	0.1372	0.3237	0.3203	0.0003	0.0033	0.0073	0.0065
70	0.0317	0.4413	0.5379	0.4356	0.0010	0.0139	0.0148	0.0103
80	0.4225	1.0012	0.7530	0.5387	0.0208	0.0433	0.0255	0.0147
90	2.5416	1.5965	0.9276	0.6227	0.2352	0.1010	0.0393	0.0197
100	4.2897	1.9178	1.0387	0.6848	1.1688	0.1884	0.0555	0.0251
110	2.8408	1.8592	1.0827	0.7253	3.4186	0.2954	0.0733	0.0307
120	0.9037	1.5386	1.0692	0.7466	3.3457	0.4027	0.0919	0.0366
130	0.1793	1.1371	1.0135	0.7516	1.1239	0.4869	0.1108	0.0426
140	0.0486	0.7800	0.9316	0.7437	0.4599	0.5318	0.1292	0.0486
150	0.0299	0.5138	0.8367	0.7259	0.4268	0.5371	0.1468	0.0545

six-fold, but the patterns remain the same. The conclusion is that investors who wish to obtain exposure to jump and gamma risk will hold at-the-money and out-of-the-money options, with a relatively short time to maturity.

Investors who do not want this exposure have several alternatives. One is to trade multiple options, for example by trading spreads or synthetic positions in the stock (i.e., by simultaneously buying a call and selling a put). Such strategies can potentially be undertaken with both long and short-term options and at any moneyness, so they would not explain concentration of trading in options with particular maturities or degrees of moneyness.[3]

In the empirical work we assign options to categories depending on whether the option delta is less 0.25, greater than 0.75, or in between. The numbers in Table 1 provide some sense how this classifies options at different maturities and strikes. Just as gamma and jump risk are increasingly asymmetric across strikes as time to expiration increases, delta is also. Thus, the delta classification can differ considerably from a fixed classification based on strike price, and should serve to distinguish options with different risk characteristics.

3 Data

Data in the paper are from CRSP, Optionmetrics, the Chicago Board Options Exchange (CBOE), and the International Stock Exchange (ISE). We obtained daily price and volume data for individual equity option contracts from OptionMetrics, and the open-close Summary data from the CBOE and ISE. We use data from January 2007 through April 2009 and we restrict attention to stocks in the S&P 500.

3.1 Option and Stock Prices

The end-of-day data from OptionMetrics includes identifying information for the options (strike price, expiration date, call or put, ticker symbol of the underlying stock, SIC code), volume for each distinct contract, price, open interest, best bid and offer prices, and option Greek measures, including delta and gamma.

Data on underlying stocks comes from the Center for Research in Security Prices (CRSP), which provides daily closing prices, volume, shares outstanding, daily returns, dividend payouts, and SIC codes. Data on the S&P500 are from Yahoo.

3.2 Open/Close Option Volume

The open/close data provide an exchange-level daily summary of signed volume for each option. All options traded on a U.S. exchange generate an entry with the Options Clearing Corp, the U.S. options clearinghouse. Each trade can

[3]The individual equity options we analyze are all American-style options. The possibility of early exercise increases the prices of options and potentially complicates the use of options to create a synthetic stock position.

either open or close a position. If the investor buys a 40-strike June call, this trade can either generate a new position in the option with the clearinghouse, or it can offset an existing written position in the same option. Trades occuring at the exchange are categorized by whether the trade order is placed by a customer or firm (meaning a proprietary trading operation of a clearing member), and for customers, by the size of the order that generated the trade (1-100, 101-200, and greater than 200).[4] Trades can be a buy or sell, and they can open a position or close a position, so there are four categories for each option. We refer to these categories as "buy to open", "buy to close", "sell to open", and "sell to close". Trades from the CBOE and ISE together constitute about half of total trading volume.

Several comments about this data are in order. First, the CBOE and ISE represent more than half of equity option trades on U.S. exchanges. We have no reason to think that trading on these exchanges is atypical, but it does not represent all exchange-traded volume. Second and perhaps more importantly, similar but not identical options can be bought and sold by the same investor. For example, an investor might buy a 40-strike call and sell a 45 strike call; this would be represented as two transactions in the open-close data. We have no way to know whether they were undertaken by the same investor or different investors. In the same vein, an investor could buy options on a set of large stocks and sell an option on the S&P 100 index. We have no way to detect such offsetting positions. Finally, investors can use over-the-counter (OTC) transactions to hedge an exchange-traded position. This would be an issue only for professional traders, but we have no information about OTC transactions.

Aggregate exchange trading volume reported for options counts a buy/sell pair as a transaction. Each transaction reflected in the open/close data can be between two non-market-makers or between a non-market-maker and a market-maker. To summarize the possible evolution of positions in the open/close data, it can be helpful to consider the possible results of a transaction. Figure 2 shows the possible results of a transaction.

Suppose that a customer (non-market-maker) buys one option, either to open or close a position. Table 2 shows the effect on open interest, net buys, and total volume (which is +1 in each case). If the customer buying is opening a position, and transacts with a customer selling to close a position, open interest is unchanged. Similarly, if the buyer is closing a short position and transacts with a seller closing a long position, open interest is unchanged. However, if the buyer is opening and transacts with a customer selling to open, open interest goes up by one. In the same way, if both buyer and seller are closing their positions, open interest goes down by one. This is the case whether the counterparty is a customer or a market-maker. Our definition of a net buy depends upon whether the counterparty is a market-maker: if so, the transaction results in a positive net buy, but it is zero otherwise since one customer has

[4] The categorization is based on the size of the order generating the trade, not the size of the trade that results. An order for 300 options might result in a trade of 50 options; this would be characterized as a large trade even though the realized quantity makes it appear to be a small trade.

Figure 2: Possible transactions in the open/close data and the effect on open interest, assuming that a customer buys, either to open or close a position. The entries in the table are the change in open interest. The two left-hand columns represent transactions among customers and the two right-hand columns represent a transaction with a market-maker. In all cases, volume is increased by one.

	Customer or firm		Market-maker	
	Sell to open	Sell to close	Sell to open	Sell to close
Buy to open	+1	0	+1	0
Buy to close	0	-1	0	-1
	Net buy = 0		Net buy = +1	
	Volume = +1		Volume = +1	

accomodated another customer's position.

We define "total buys", "total sells", and "net buys" for a given option series i on day t as

$$\begin{aligned} \text{Total buys}_{it} &= \text{Buys to open}_{it} + \text{buys to close}_{it} \\ \text{Total sells}_{it} &= \text{Sells to open}_{it} + \text{sells to close}_{it} \\ \text{Net buys}_{it} &= \text{Total buys}_{it} - \text{Total sells}_{it} \end{aligned}$$

Assuming that the open/close data is complete, net buys would measure the end-of-day exposure that must be absorbed by market-makers. Because the open/close data only includes trades from two exchanges, it provides a noisy measure of market-maker exposure that will be downward biased on average.[5] We also compute gamma-volume, which for each bucket k for each day we measure as

$$\text{Gamma volume}_{kt} = \sum_{i=1}^{n_k} \Gamma_{it-1} \text{NetBuys}_{it}$$

where the sum is over options in the bucket and Γ_{it-1} is the previous day's gamma for option series i.

Once we match the Optionmetrics and open/close data from January 2007 to April 2009, we have 383 million unique option/date/ticker records. To make the data tractable, for each ticker for each day we construct nine option "buckets" based on option moneyness and maturity. We classify calls as in-the-money, at-the-money, or out-of-the-money, based on whether the Optionmetrics delta *the previous day* is above 0.75, between 0.75 and 0.25, or below 0.25.[6] For the same delta categories, puts are out-of-the-money, at-the-money, or in-the-money. Since calls are in-the-money when puts are out-of-the-money and vice

[5]If orders are randomly distributed across exchanges, then the average ratio of true to measured net buys will be proportional to the fraction of volume captured in the open-close data.

[6]In many cases, Optionmetrics has a missing value for delta. However, every missing-delta case we examined was for a deep in-the-money or deep out-of-the-money option. In those cases, we assign a delta of 0.01 or 0.99 for a call or -0.01 or -0.99 for a put.

versa, some of our tables use the nomenclature M1, M2, and M3, to refer to low-strike, medium-strike, and high-strike options, where the cutoffs between strike categories are determined by delta. Similarly, we use “near”, “mid”, and “far” to describe maturity buckets. So a low strike (high delta) near-term call is in the category “M1near”. For puts, the same category contains low-strike, low-delta options.

The classification based on delta differs from that in Lakonishok et al. (2007), who classify options based on strike price. An option with a strike price that is 10% below the stock price will have different economic characteristics at different times to maturity. With one week to maturity, such an option will be deeply in-the-money, with a delta close to one. With two years to maturity, it will have a lower delta, and possibly be classified as at-the-money. The drawback of delta-based classification is that it potentially complicates the interpretation of volume and open interest, as changes in the stock price (and less dramatically, changes in time) can move options into different categories. Of course a strike-price based classification will fail to reclassify options when their economic characteristics change.

We base the delta classification on the lagged delta in order to avoid mechanically-induced intra-day assignment to delta buckets. The option delta in the Optionmetrics database is not determined until the end of the day. If we used the contemporaneous delta to assign options to buckets, then on days with a large price rise, calls would mechanically be deemed more in-the-money (delta would have increased), and thus volume in the in-the-money category would be high. By using a lagged delta, we fix the bucket assignments during the day. Of course, as prices change during the day, the economic characteristics of options will change and relative trading volume will change for that reason, so using a predetermined delta is not perfect either.

In creating maturity buckets, we define near-term as the nearest and next-to-nearest expiration date, mid-term is the third and fourth nearest expiration dates, and far-term is everything else. For example, an option bought or sold on January 1 that expires in January or February is categorized as near-term. An option with a February or March expiration bought or sold on January 30 (which date is past the third Friday in January) would also be categorized as near-term. The practical problem with maturity buckets is that, however constructed, the options in a bucket will be constant for approximately a month, at which time one set of options will expire, and one day later new options will typically start trading. There is thus a “lumpiness” in the definition.

To understand better the effect of the maturity classification, it is necessary to understand how the options exchanges determine expiration months. Stocks are assigned to one of three quarterly expiration cycles, called the January, February, and March expiration cycles. The January cycle includes January, April, July, and October. On any date there are at least four options trading with expirations of less than one year, and among large stocks, generally at least one option expiring in more than one year, always in January. These longerterm options are known as LEAPS (Long-term Equity Anticipation Securities).[7] Equity options expire on the Saturday following the third Friday of each month. The option closest to expiration is known as the front month. There are always options trading for the front and following months. In addition, a new two-year LEAPS is issued in September (January cycle), October (February cycle) or November (March cycle). We will consider several scenarios to understand variations in maturity within the buckets.

1. January 1, 2010: A January cycle option will have January, February, April, and July options trading, in addition to options (LEAPS) expiring in January 2011 and January 2012. Thus, the near bucket will have maturities of about two weeks and seven weeks. The mid bucket contains options expiring in April and July, with maturities of approximately 90 to 180 days.

2. January 15, 2010. With the January option expiring, the near bucket contains options of at most 5 weeks to expiration. The mid bucket has maturities of approximately 75 to 165 days.

3. January 18, 2010: The expiring January options stop trading on January 15 (the third Friday of January). The following Monday, January 18, February becomes the front month and a new March option will start trading, so maturities jump to 30 to 60 days in the near bucket. Note that the options in the mid bucket are unchanged.

4. February 22, 2010: The February options have expired. March is the front month and the new option expirations will be March, April, July, and October. The last begins trading to ensure that there are four options with expiration less than one year. The maturities in the mid bucket are now approximately 150 to 210 days.

One final complication is that the January LEAPS are "off-cycle" for non January-cycle months. So when September is the front-month, February cycle options will have September, October, (these are the two front months), November (a cycle month), January (a LEAPS month) and February (a cycle month) trading.

The buckets are necessarily coarse. There will be jumps in average maturity due to of discreteness in expiration dates. A virtue of our algorithm is that options switch buckets on clearly-defined dates. A disadvantage is that there are considerable swings in time to expiration. This is to some extent inevitable, given the lumpiness of monthly expirations.[8]

[7] Apart from time to expiration, there is no meaningful economic distinction between standard options and LEAPS, although the terminology is still in use. Generally LEAPS trade only on options with an average daily trading volume of at least 1000 contracts.

[8] There are now weekly options trading for some stock. We do not have these options in our sample.

4 Empirical Model

The goal is to explain volume, gamma volume, and open interest in equity options as a function of economic variables, including option expiration, earnings announcements, dividend payments, interest rates, VIX, and various episodes of the financial crisis, including the Bear Stearns takeover, the Lehman failure, and short-sale restrictions.

The basic regression equation is

$$\ln(\mathrm{Vol}_{ijkt}) = \alpha_{ijk} + \beta_0 \ln(\mathrm{VolStock}_{it}) + \beta_{jk} X_{it} + \gamma_{jk} Y_t + \epsilon_{ijkt} \tag{2}$$

where Vol_{ijkt} is the trading volume on day t for options on stock i in maturity/moneyness bucket j in category k, where category can be aggregate volume, gamma-weighted volume, buys to open, buys to close, sales to open, or sales to close. Some explanatory variables vary with the stock and time (X_{it}) and others vary over time and are common across stocks (Y_t). To account for endogeneity with equity options (high option volume could induce high stock volume as market-makers delta-hedge) we instrument stock volume using lagged stock volume, lagged option volume, and lagged S&P volume.

We estimate equation (2) by OLS with stock fixed effects and clustering by stock. We limit stocks to those in the S&P 500 to ensure that we capture only actively-traded options. The time period of our analysis is January 2007 to April 30, 2009, which includes the period of recent financial market volatility and economic recession. By examining this time period we are able to analyze the impact of extreme market volatility on options volume.

4.1 Explanatory Variables

The regressors are variables that seem likely to affect trading in options or that prior research has found likely to affect trading: events that give rise to volatility, variables that affect the cost of leverage implicit in the option, and so forth.

We control for both stock and option-specific variables as well as general economic variables. Stock and option-specific variables include

- contemporaneous stock volume, instrumented by lagged stock volume and lagged market volume
- lagged stock return of the individual stock. One motivation is that a large return would be associated with an accumulation or decumulation of option positions that would be reversed in subsequent days.
- lagged mean implied option volatility, computed by averaging across stocks in a given bucket
- earnings announcement date, with dummy variables for the 9 trading days preceding and following the announcement

- Earnings forecast dispersion. This is the variable used in Diether et al. (2002), with the standard deviation of analyst forecasts divided by the stock price serving as a measure of market uncertainty about the firm. This is expressed as percentage points.
- Dummies for the option expiration date and 9 days leading up to and following expiration
- dividend record date (dummy) and dummies for the day preceding and following
- lagged option open interest, computed within the bucket

Economy-wide explanatory variables include

- dummies for days leading up to and after the sale of Bear Sterns in March 2008
- dummies for days leading up to and after the failure of Lehman Brothers
- dummies for short-sale restrictions in September and October of 2008, and for naked-short restrictions in July 2008 (since not stocks were affected by the restrictions, these are applied on a stock-by-stock basis)
- the VIX index
- S&P 500 stock volume,
- the Fed funds rate. Since there is an implicit interest cost in option, changes in the interest rate might be associated with
- The 2-year Treasury rate
- The 3-month LIBOR-OIS spread. This rate difference was widely used as a measure of market stress during the financial crisis

5 Data Summary

In this section we present summary statistics. From this point on we restrict the equity option sample to the 125 stocks in the S&P 500 with the greatest option trading volume. This accounts for about 80% of the option trading volume in S&P 500 stocks, or about 5 million contracts daily out of over 6 million traded on S&P 500 stocks. Figure 3 shows the cumulative distribution of volume, making it clear that the low volume firms in the S&P 500 have significantly lower relative volume.

Summary statistics for explanatory variables are in Table 2. As documented by earlier papers, call volume and open interest exceed put volume and open interest; both exhibit considerable skew. Special announcements — economic statistics, FOMC meetings — occur about once every 20 days. Dividend record

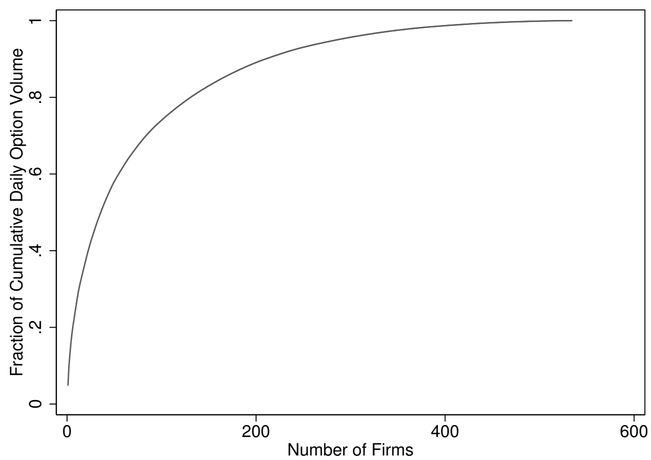


Figure 3: Cumulative trading volume for tickers on stocks in the S&P 500, sorted by option trading volume.

dates are 1% of trading days but Pool et al. (2008) find that these days account for about 15% of call volume on dividend-paying stocks. The very large maximum earnings dispersion estimate is from AIG. The sample contains two other comparable dispersion values, from AIG and MBIA.

Figure 4 displays some basic properties of equity option volume for the top 125 stocks. The top left panel shows that almost 50% of stocks in the top 125 have average daily volume between 10,000 and 20,000 contracts. Citigroup and Apple are outliers, with each having average daily volume of approximately 270,000 contracts. The top right graph shows that the ratio of open interest to shares outstanding is below 10% for most stocks, but reaches as high as 33%. The bottom left graph shows what might be termed "turnover": the ratio of volume to open interest by bucket. Table 2 shows that the ratio of open interest to volume is about 20. The figure shows that turnover is lowest for far maturity options. Short maturity options exhibit a higher ratio of volume to open interest. Finally, the bottom right graph depicts a histogram of option volume to stock volume, both measured per share. At the far right, Google's option volume on average exceeds share volume by 50%. For most option the ratio is well below 0.5.

Figure 5 summarizes information about volume and open interest in equity options, by bucket, broken down for puts and calls. Values at the ticker level are averaged over time, so the cross-sectional dispersion in these graphs is due to variation across tickers, not within a ticker. The top panels shows volume histograms by bucket, based on average volume. Skewness is evident, as is the greater volume in calls and greater volume at near maturities. For all buckets, most firms have volume below 5000 contracts per day. Exceptions in the graph are apparent.

Table 2: Summary statistics for the variables used in the regressions.

	Mean	Std Dev	Median	Skewness	Minimum	Maximum	Observations
Daily Call Volume	20591.838	67786.425	9296.000	47.084	0.000	7412460.000	611319
Daily Put Volume	15463.130	32330.734	6890.000	10.079	0.000	1505911.000	612328
Call Open Interest	430727.638	462700.856	286725.000	3.580	1152.000	8695562.000	611319
Put Open Interest	345472.376	377104.618	224682.500	3.357	358.000	6400372.000	612328
Earnings Dummy	0.017	0.128	0.000	7.553	0.000	1.000	1223647
Dividend Dummy	0.011	0.105	0.000	9.313	0.000	1.000	1223647
Earnings Forecast Dispersion	0.007	0.037	0.002	26.077	0.000	1.366	890432
Expiration Day	0.048	0.213	0.000	4.254	0.000	1.000	1223647
LIBOR-OIS spread	0.754	0.643	0.714	1.767	0.065	3.644	580
Fed Funds	3.004	1.970	2.940	-0.183	0.080	5.410	580
Two-year T-bill	2.858	1.455	2.560	0.105	0.650	5.100	580
VIX	27.671	14.826	23.170	1.264	9.890	80.860	580
CPI Announcement	0.048	0.214	0.000	4.236	0.000	1.000	580
Employment Announcement	0.046	0.210	0.000	4.326	0.000	1.000	580
FOMC Meeting	0.050	0.217	0.000	4.150	0.000	1.000	580
FOMC Meeting	0.050	0.217	0.000	4.150	0.000	1.000	580

Figure 4: Total volume measures, puts and calls combined, for the top 125 options.

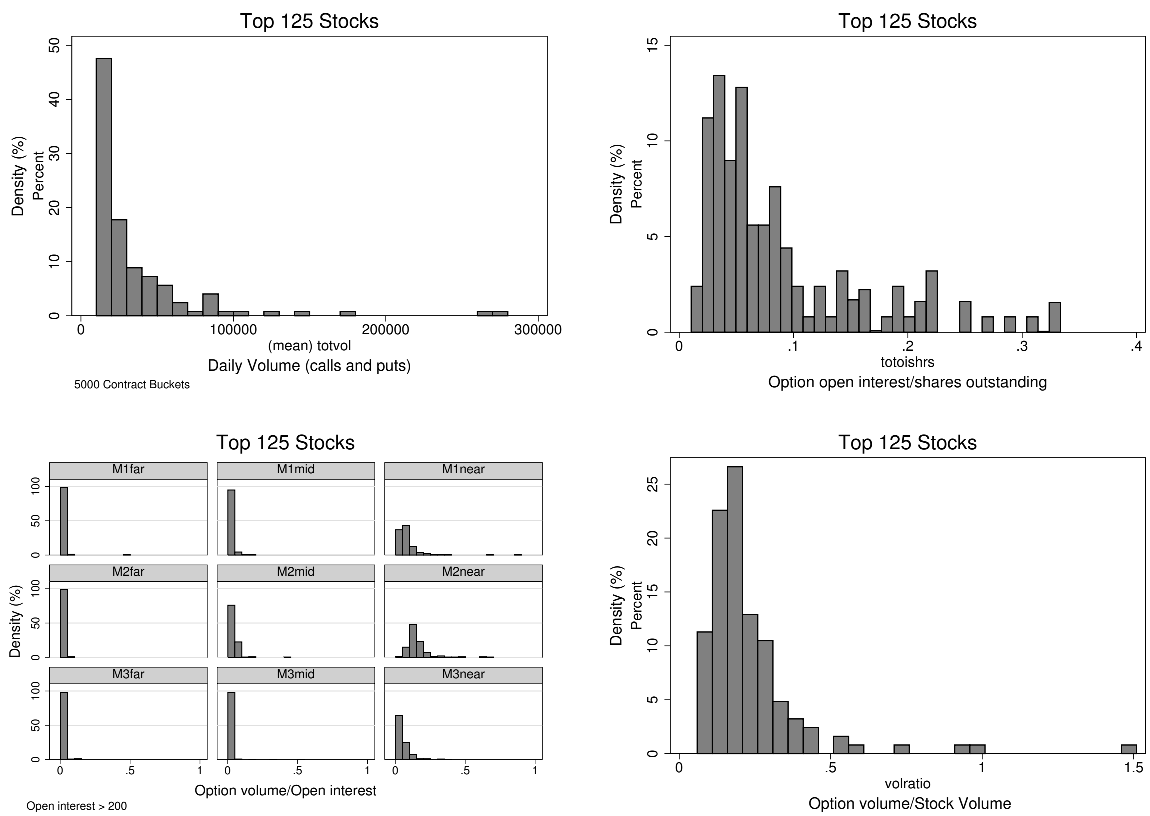


Table 3: Daily volume summary statistics for calls (first panel) and puts (second panel) by category of trader.

Variable	Mean	Std. Dev.	Min.	Max.
Large customer buys	1604.075	6400.032	0	470972
Medium customer buys	540.316	1681.838	0	112357
Small customer buys	2425.588	6106.300	0	311530
Large customer sells	1611.882	7072.514	0	630782
Medium customer sells	558.293	1748.041	0	138871
Small customer sells	2603.983	6240.029	0	356099
Firm buys	1742.462	5402.55	0	275641
Firm sells	1546.624	4907.686	0	287373
Large customer buys	1131.417	4999.731	0	315617
Medium customer buys	330.704	997.798	0	55294
Small customer buys	1402.014	3572.469	0	200253
Large customer sells	1103.214	4460.060	0	264314
Medium customer sells	344.989	981.641	0	55639
Small customer sells	1489.568	3684.065	0	193231
Firm buys	1440.664	4250.536	0	281308
Firm sells	1282.086	4448.994	0	283994
N		68046		

The center figures in Figure 5 display relative volume: the fraction of volume for a firm accounted for by options in a bucket. For both puts and calls, in-the-money options account for a small percentage of volume — at-the-money and out-of-the-money options are more important, as evidenced by the histogram weight in greater percentile categories.

Finally, the bottom two figures show there is considerably more open interest than volume in the various buckets. The greater open interest for long-term and in-the-money options suggest that turnover is lower in those categories.

Summary statistics for the four categories of signed volume (customer orders for 1-100 contracts (small), 101-200 contracts (medium) and more than 200 contracts (large), and for firm volume are presented in Table 3. Small customers represent the largest volume category, followed by firms and large customers. Medium customers are a distant fourth.

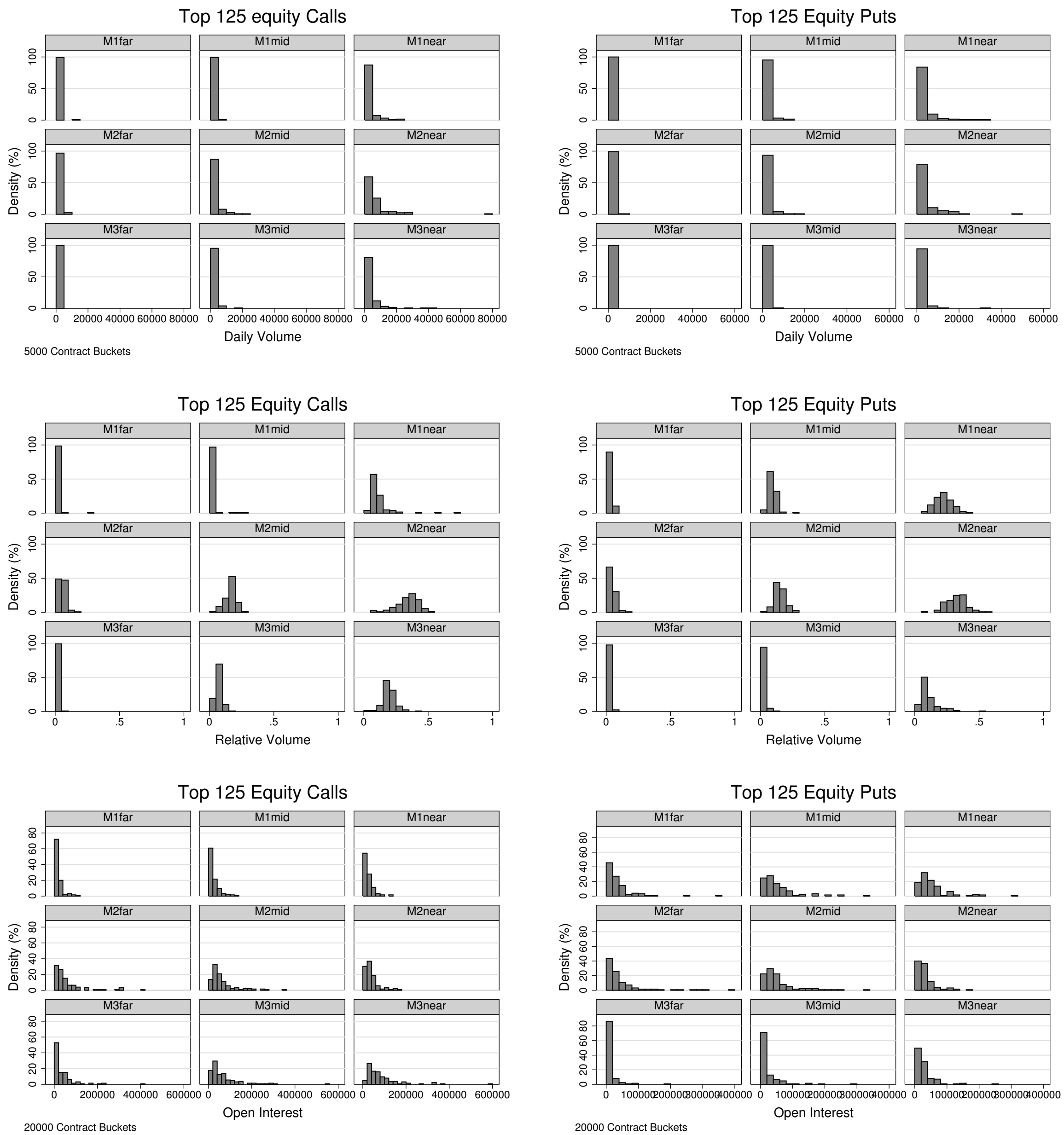
The sum across categories for calls and puts is less than the average daily volume reported in Table 2 to the extent that the CBOE and ISE volume numbers do not represent the entire market (total volume in Table 3 is about 60% of that in Table 2).

6 Results

For each of the nine buckets and for puts and calls separately, we run 7 regressions which have as dependent variables total volume, the four open close

Figure 5: Volume, relative volume, and open interest, by bucket, for the top 125 equity calls and puts.

Calls Puts



categories (buy to open, buy to close, sell to open, sell to close), gamma volume, and open interest. Thus we have 126 regressions, each with 93 explanatory variables, including dummies. We also run regressions in which we use total buys and totals sells as the dependent variable, broken down by customer and firm categories. The volume and open interest regressions have log volume as the dependent variable, whereas gamma volume (which can be negative) is not transformed. R-squareds for the regressions are in the vicinity of 0.3 for the total volume and open/close regressions, 0.005 for the gamma regressions, and 0.7 for the open interest regressions.

Because it is difficult to absorb and interpret this volume of output, we present results for specific explanatory variables, both graphically and in tables.

6.1 Stock Volume

Table 4 presents estimates for β_0 in equation (2). Several points stand out. First, the coefficient is close to 1 for most of the unweighted volume regressions: When volume for the stock increases, volume for most option increases proportionately. There is also an increase in open interest, with estimated elasticities generally less than 0.10 (we would not expect open interest to increase by the same percentage as volume).

Gamma volume estimates are generally small and insignificant, suggesting that an option volume increase associated with a stock volume increase does *not* generally lead to greater inventory for market-makers. To interpret the coefficients, gamma for a near term at-the-money option can be around 0.05. A coefficient of 1.0 thus implies that an increase of 1 in the log of stock volume (a tripling of volume) results in non-market-makers buying 20 more options, which means that market-makers must sell 20 options. The significant coefficients in Table 4 are negative, which implies that on high volume days, non-market-makers sell options to market-makers.

6.2 Earnings

Since Patell and Wolfson (1979, 1981) it has been widely recognized that earnings announcement days are of special interest for option traders. They focused on option pricing, specifically the extent to which option prices reflected the greater uncertainty associated with earnings announcements. We find that earnings days have a large effect on volume but not on open interest, suggesting that much of the trading on earnings announcement days is very short term.

Equation (2) includes dummy variables for the 9 days preceding and following an earnings announcement, and one for the day itself. The coefficients on the dummy variables represent a change in one for the log of volume, so a 1.0 represents an increase by a factor of e (about 278%). Figure 6 plots the regression results for calls, for each moneyness/expiration bucket. In each subfigure, we plot the coefficients for total volume and for each of the open-close categories. It is important to remember that the open-close volume is not equal to total volume. Even if it were, the open-close coefficients would not sum to

Table 4: The table reports the coefficient on ln(Stock Volume) in the 126 regression. Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and other explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	1.0036***	1.0664***	1.2189***	1.1308***	1.0459***	1.0775***	1.1091***	1.0568***	1.1478***
	(0.0480)	(0.0420)	(0.0675)	(0.0478)	(0.0432)	(0.0459)	(0.0546)	(0.0491)	(0.0635)
Call: buy to close:	0.7237***	1.1624***	1.2079***	0.5127***	1.2993***	0.9443***	0.3787***	0.8977***	0.5746***
	(0.0538)	(0.0799)	(0.0762)	(0.0528)	(0.0625)	(0.0722)	(0.0731)	(0.0643)	(0.0928)
Call: sell to close:	1.1489***	1.4713***	1.5416***	0.8223***	1.4682***	1.0090***	0.6794***	1.1858***	0.6714***
	(0.0579)	(0.0709)	(0.0760)	(0.0678)	(0.0684)	(0.0866)	(0.0860)	(0.0771)	(0.1084)
Call: buy to open:	1.2632***	1.5145***	1.7090***	0.9260***	1.7031***	1.2508***	0.8515***	1.4459***	0.8941***
	(0.0618)	(0.0674)	(0.0801)	(0.0707)	(0.0669)	(0.0803)	(0.0915)	(0.0826)	(0.1147)
Call: sell to open:	1.0293***	1.1654***	1.4725***	0.6290***	1.4154***	1.0385***	0.5224***	1.1637***	0.6633***
	(0.0684)	(0.0664)	(0.0800)	(0.0580)	(0.0645)	(0.0721)	(0.0778)	(0.0733)	(0.1005)
Call: gamma volume:	-5.4503**	-27.8778**	0.4655	-0.3616	-0.1251	-0.4241	0.7147	0.9068	0.2750
	(1.7955)	(8.4845)	(2.3846)	(0.3701)	(2.9840)	(0.7873)	(0.5276)	(1.5735)	(0.3431)
Call: open interest:	-0.0425**	0.1028***	0.0281*	0.0145	0.0489***	0.0413***	-0.0193	0.0151*	0.0426***
	(0.0155)	(0.0118)	(0.0116)	(0.0115)	(0.0087)	(0.0106)	(0.0099)	(0.0070)	(0.0104)
Put: total volume:	1.1089***	1.0542***	1.2127***	1.0951***	0.9879***	1.1754***	0.9964***	0.9742***	0.9309***
	(0.0543)	(0.0528)	(0.0505)	(0.0617)	(0.0639)	(0.0542)	(0.0667)	(0.0646)	(0.1002)
Put: buy to close:	1.1888***	1.3192***	0.9997***	0.9899***	1.2808***	0.4067***	0.5723***	0.6521***	0.2920***
	(0.0727)	(0.0753)	(0.0608)	(0.0732)	(0.0944)	(0.0555)	(0.0766)	(0.0761)	(0.0874)
Put: sell to close:	1.4703***	1.5375***	1.2484***	0.9977***	1.2826***	0.4392***	0.4517***	0.5422***	0.1954**
	(0.0753)	(0.0919)	(0.0673)	(0.0823)	(0.1074)	(0.0526)	(0.0662)	(0.0635)	(0.0604)
Put: buy to open:	1.6440***	1.6045***	1.2050***	1.4004***	1.6608***	0.3933***	0.6987***	0.7165***	0.2125**
	(0.0784)	(0.0929)	(0.0681)	(0.0914)	(0.1356)	(0.0471)	(0.0793)	(0.0707)	(0.0706)
Put: sell to open:	1.3821***	1.3291***	1.0380***	1.3206***	1.5813***	0.4452***	0.8690***	0.9325***	0.3271***
	(0.0789)	(0.0745)	(0.0617)	(0.0879)	(0.1005)	(0.0646)	(0.0752)	(0.0833)	(0.0943)
Put: gamma volume:	2.4633	-7.0994	-1.3651	0.8024	2.2574	-0.2149	-0.7145	0.2596	0.1416
	(2.1334)	(4.9393)	(0.9200)	(0.6628)	(1.7638)	(0.2555)	(0.6092)	(1.0595)	(0.1031)
Put: open interest:	-0.0208	0.1246***	0.0853***	0.0082	0.0629***	0.0455**	-0.0283**	0.0188*	0.0117
	(0.0117)	(0.0140)	(0.0188)	(0.0088)	(0.0098)	(0.0150)	(0.0091)	(0.0085)	(0.0181)

the total volume coefficient because the coefficients are elasticities, not dollar amounts.

Several patterns are immediately evident in Figure 6. For all of the graphs, the volume effect shows a peak on day 0 or day -1 (the day before the earnings announcement). the effect is greatest for at-the-money and out-of-the-money options, with the greatest effect for the near-term options. This makes sense on several counts. First, the effect of the earnings announcement will have the greatest relative effect for a short term option. Second, at-the-money options will have the greatest sensitivity to volatility. Third, out-of-the-money options will have the greatest sensitivity to jumps.

The volume coefficients show the greatest relative effects on buys to open until day 0, after which the greatest effect is sales to close. This is consistent with investors purchasing calls and selling them after the earnings announcement.

The same qualitative patterns are evident for puts in Figure 7. Again there is a surge in buys followed — after day 0 — by sells for the at-the-money and out-of-the-money near-term puts. The fact that both buys of puts and call increase is consistent with a number of trading strategies, including outright option purchases, straddles, and strangles (out-of-the-money call bought with out-of-the-money puts).

Tables 5, 6, and 7 display the coefficients for all volume regressions for the dummy variables for the day before, day of, and day after the earnings announcement. Examine the gamma volume rows. Of interest is the fact that gamma volume is positive while open interest is generally unchanged or lower as a result of the earnings announcement. This implies that traders generally are holding positive gamma positions (generally buying options) and imposing the risk on option market-makers. This is consistent with anecdotes about traders generally buying options prior to earnings announcements. The gamma of an at-the-money option that is not extemely close to maturity is likely to be about 0.05. Each option is on 100 shares. A coefficient of 1 means that market-makers are absorbing options with a notional share amount of 2000 shares. A coefficient of 20 represents an increase in 400 options (on 40,000 shares). The gamma volume coefficients show that traders the day before an announcement on net buy near-term at-the-money puts (coefficient of 35) and calls (coefficient of 91). The buying continues on day 0 and is reversed on day +1. These effects are interesting but not large. A coefficient of 91 for a near-term at the money option suggests that market-makers have to absorb 1800 at-the-money calls and 700 at-the-money puts.

Despite the volume, open interest also does not increase. The fact that gamma volume and open interest effects are small can mask trading among the various categories of non-market-maker trader. With the open/close data we are able to examine the extent to which groups trade among themselves. To determine which groups of traders are buying and which are selling, we run the volume regressions separately for the three customer categories and firms. Figures 8 - 11 plot the earnings coefficients broken down by customer and firm categories for call and put buys and sells. In all of these graphs, the coefficients that are *visually* non-zero also turn out to be *statistically* non-zero.

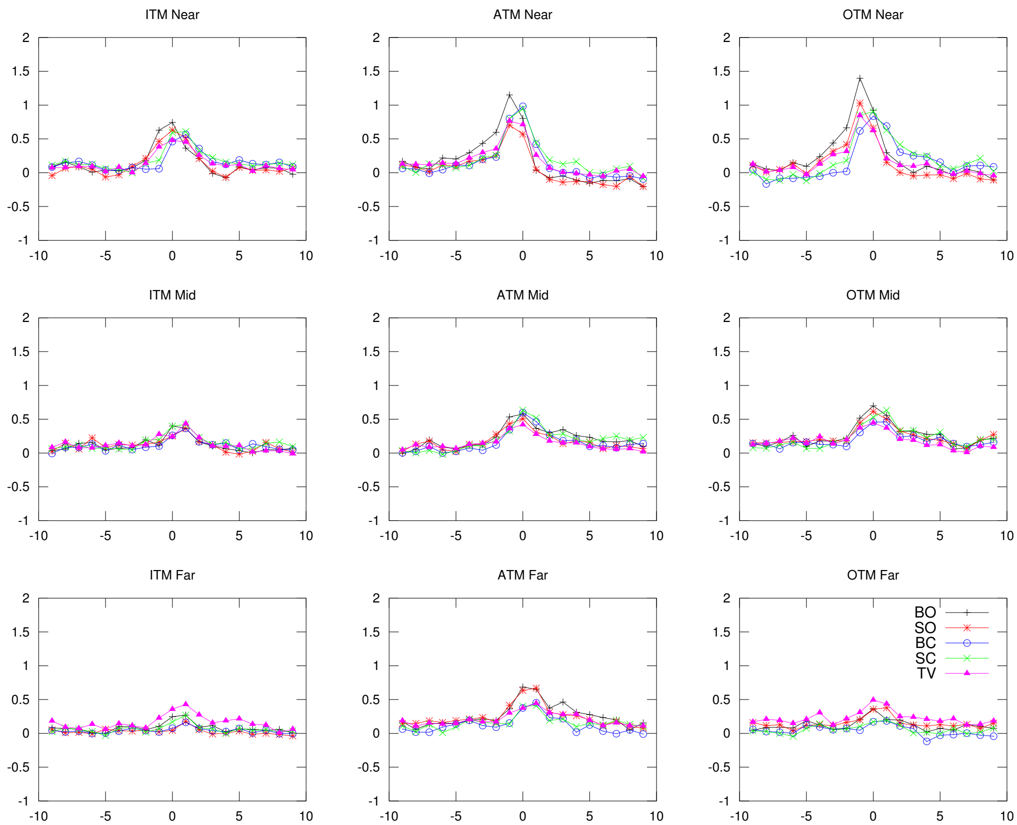


Figure 6: Effect of earnings announcements on call volume. Plotted points are regression coefficients for dummy variables from equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, "BO" means a buy to open a position; "SO" means a sale to open a position; "BC" means a buy to close a position; "SC" means a sale to close a position; "TV" means total volume in that category of options.

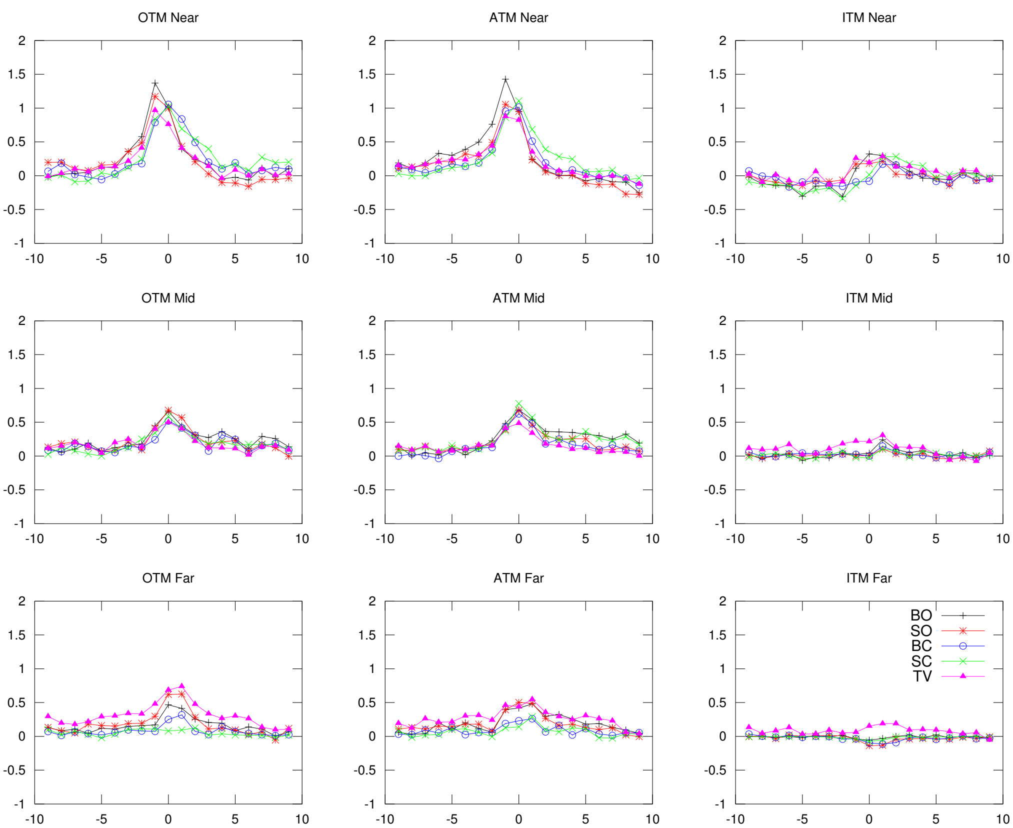


Figure 7: Effect of earnings announcements on put volume. Plotted points are regression coefficients for dummy variables from equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, "BO" means a buy to open a position; "SO" means a sale to open a position; "BC" means a buy to close a position; "SC" means a sale to close a position; "TV" means total volume in that category of options.

Table 5: Day before an earnings announcement. The table reports 126 dummy variables coefficients, from that many estimates of equation (2), for the day being one day before an earnings announcement. Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	0.3836***	0.7657***	0.8468***	0.2783***	0.3608***	0.3740***	0.2276***	0.3014***	0.3111***
	(0.0525)	(0.0418)	(0.0558)	(0.0506)	(0.0361)	(0.0501)	(0.0494)	(0.0447)	(0.0616)
Call: buy to close:	0.0600	0.8009***	0.6202***	0.1030*	0.3469***	0.3052***	0.0206	0.1518**	0.0460
	(0.0696)	(0.0690)	(0.0843)	(0.0420)	(0.0620)	(0.0704)	(0.0288)	(0.0482)	(0.0493)
Call: sell to close:	0.1854**	0.7999***	0.8540***	0.1994***	0.3267***	0.4032***	0.0689	0.1390**	0.1037*
	(0.0706)	(0.0687)	(0.0963)	(0.0506)	(0.0656)	(0.0648)	(0.0404)	(0.0510)	(0.0490)
Call: buy to open:	0.6293***	1.1506***	1.3976***	0.1146*	0.5342***	0.5168***	0.1045*	0.3627***	0.2117**
	(0.0787)	(0.0739)	(0.1002)	(0.0557)	(0.0605)	(0.0688)	(0.0441)	(0.0584)	(0.0664)
Call: sell to open:	0.4631***	0.7048***	1.0298***	0.1618**	0.4312***	0.4469***	0.0222	0.4164***	0.1992***
	(0.0755)	(0.0605)	(0.0896)	(0.0530)	(0.0632)	(0.0686)	(0.0365)	(0.0701)	(0.0597)
Call: gamma volume:	4.5397*	91.1248***	19.5496***	-1.1946	0.9073	0.3138	-0.4597	-5.1610	0.7199*
	(2.2016)	(19.5269)	(5.6364)	(0.9292)	(3.7410)	(1.8957)	(0.3414)	(3.0653)	(0.3386)
Call: open interest:	-0.1120***	0.0057	-0.0707**	0.0106	0.0032	-0.0071	0.0364*	0.0084	0.0412**
	(0.0323)	(0.0258)	(0.0243)	(0.0187)	(0.0109)	(0.0149)	(0.0155)	(0.0099)	(0.0128)
Put: total volume:	0.9678***	0.8776***	0.2604***	0.4005***	0.4127***	0.2208***	0.4797***	0.4608***	0.0613
	(0.0566)	(0.0466)	(0.0626)	(0.0518)	(0.0400)	(0.0629)	(0.0593)	(0.0594)	(0.0623)
Put: buy to close:	0.7882***	0.9539***	-0.0928	0.2429***	0.4272***	0.0240	0.0747	0.1901***	-0.0356
	(0.0843)	(0.0742)	(0.0750)	(0.0650)	(0.0666)	(0.0356)	(0.0386)	(0.0516)	(0.0292)
Put: sell to close:	0.8382***	0.8644***	-0.1411	0.3403***	0.3742***	-0.0225	0.1087**	0.1274**	-0.0351
	(0.0847)	(0.0744)	(0.0761)	(0.0740)	(0.0656)	(0.0382)	(0.0340)	(0.0480)	(0.0227)
Put: buy to open:	1.3698***	1.4293***	0.1070	0.4459***	0.4824***	0.0242	0.1696**	0.3970***	-0.0380
	(0.0972)	(0.0904)	(0.0763)	(0.0834)	(0.0734)	(0.0385)	(0.0574)	(0.0609)	(0.0287)
Put: sell to open:	1.1738***	1.0560***	0.1731*	0.4143***	0.3919***	0.0024	0.2971***	0.3937***	-0.0443
	(0.0862)	(0.0751)	(0.0757)	(0.0772)	(0.0771)	(0.0368)	(0.0665)	(0.0605)	(0.0285)
Put: gamma volume:	3.6095	34.9920**	-1.5482	1.0777	2.1540	-0.1826	-0.9115	2.0935	-0.0900
	(3.7825)	(11.7178)	(1.8535)	(1.5319)	(4.3422)	(0.2865)	(0.6752)	(3.1540)	(0.1002)
Put: open interest:	-0.0669*	0.0165	-0.0883*	0.0145	0.0001	0.0232	0.0290*	0.0161	0.0337
	(0.0288)	(0.0271)	(0.0383)	(0.0161)	(0.0111)	(0.0254)	(0.0135)	(0.0097)	(0.0332)

Table 6: Day of an earnings announcement. The table reports 126 dummy variables coefficients, from estimates of equation (2), for the day being an earnings announcement. Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	0.4798***	0.7123***	0.6244***	0.2416***	0.4214***	0.4462***	0.3578***	0.3743***	0.4944***
	(0.0598)	(0.0482)	(0.0883)	(0.0550)	(0.0443)	(0.0505)	(0.0594)	(0.0528)	(0.0624)
Call: buy to close:	0.4613***	0.9820***	0.8383***	0.2621***	0.5978***	0.4581***	0.0755	0.3781***	0.1716*
	(0.0909)	(0.0800)	(0.1033)	(0.0631)	(0.0759)	(0.0830)	(0.0520)	(0.0706)	(0.0783)
Call: sell to close:	0.5963***	0.9500***	0.9041***	0.3983***	0.6342***	0.5314***	0.1702*	0.4012***	0.1710*
	(0.0790)	(0.0836)	(0.1147)	(0.0769)	(0.0838)	(0.0857)	(0.0677)	(0.0682)	(0.0850)
Call: buy to open:	0.7438***	0.8034***	0.9241***	0.3986***	0.5777***	0.6979***	0.2471***	0.6856***	0.3638***
	(0.0912)	(0.0866)	(0.1331)	(0.0777)	(0.0871)	(0.0959)	(0.0690)	(0.0816)	(0.0873)
Call: sell to open:	0.6319***	0.5722***	0.6586***	0.2522***	0.5082***	0.6151***	0.0434	0.6340***	0.3565***
	(0.0894)	(0.0721)	(0.1333)	(0.0712)	(0.0766)	(0.0894)	(0.0635)	(0.0863)	(0.0791)
Call: gamma volume:	7.7049	43.5829	7.4058	0.2655	-3.1531	0.5936	0.1911	-0.6282	-0.0218
	(5.9777)	(27.8135)	(6.2869)	(0.7055)	(6.8196)	(2.2523)	(0.3242)	(2.1731)	(0.7210)
Call: open interest:	-0.0485	0.0357*	-0.0808**	0.0003	-0.0070	-0.0106	0.0479**	0.0198	-0.0231
	(0.0362)	(0.0171)	(0.0309)	(0.0206)	(0.0119)	(0.0167)	(0.0169)	(0.0105)	(0.0177)
Put: total volume:	0.7610***	0.8229***	0.1952**	0.5011***	0.4841***	0.2147**	0.6852***	0.4404***	0.1531
	(0.0878)	(0.0571)	(0.0675)	(0.0675)	(0.0521)	(0.0715)	(0.0668)	(0.0679)	(0.0887)
Put: buy to close:	1.0553***	1.0153***	-0.0809	0.5203***	0.6240***	0.0005	0.2515***	0.2314***	-0.0963
	(0.1034)	(0.0937)	(0.0873)	(0.0870)	(0.0841)	(0.0502)	(0.0642)	(0.0594)	(0.0598)
Put: sell to close:	1.0224***	1.1085***	0.0144	0.5862***	0.7776***	-0.0229	0.0797	0.1409*	-0.0739
	(0.1133)	(0.0969)	(0.0929)	(0.0854)	(0.0828)	(0.0628)	(0.0564)	(0.0569)	(0.0407)
Put: buy to open:	1.0177***	0.9493***	0.3228***	0.6582***	0.6820***	0.0405	0.4671***	0.4193***	-0.0558
	(0.1387)	(0.1076)	(0.0975)	(0.0956)	(0.1159)	(0.0557)	(0.0785)	(0.0846)	(0.0474)
Put: sell to open:	1.0000***	0.9520***	0.1811*	0.6777***	0.6773***	0.0089	0.6194***	0.5016***	-0.1375*
	(0.1315)	(0.0969)	(0.0917)	(0.0981)	(0.0870)	(0.0676)	(0.0800)	(0.0837)	(0.0669)
Put: gamma volume:	-12.9909**	1.1935	1.2021	-5.1100**	0.7873	0.6979	-2.1016**	-0.8867	0.0015
	(4.9988)	(13.9597)	(1.3935)	(1.9738)	(5.0088)	(0.5597)	(0.6704)	(1.1896)	(0.1057)
Put: open interest:	-0.0091	0.0228	-0.1812***	0.0141	-0.0164	-0.0368	0.0312	0.0122	-0.0377
	(0.0308)	(0.0200)	(0.0399)	(0.0144)	(0.0112)	(0.0273)	(0.0199)	(0.0116)	(0.0337)

Table 7: Day after an earnings announcement. The table reports 126 dummy variables coefficients, from estimates of equation (2), for the day being one day after an earnings announcement. Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	0.4541***	0.2601***	0.2077***	0.4373***	0.2790***	0.3700***	0.4290***	0.4448***	0.4358***
	(0.0516)	(0.0431)	(0.0597)	(0.0549)	(0.0419)	(0.0593)	(0.0610)	(0.0541)	(0.0759)
Call: buy to close:	0.5657***	0.4220***	0.6908***	0.3640***	0.4661***	0.4598***	0.1637**	0.4524***	0.1854**
	(0.0755)	(0.0903)	(0.1000)	(0.0607)	(0.0772)	(0.0860)	(0.0533)	(0.0788)	(0.0667)
Call: sell to close:	0.6083***	0.4425***	0.6290***	0.4242***	0.5182***	0.6319***	0.2700***	0.4110***	0.1962*
	(0.0831)	(0.0783)	(0.0983)	(0.0692)	(0.0771)	(0.0850)	(0.0633)	(0.0712)	(0.0790)
Call: buy to open:	0.3646***	0.0346	0.2969**	0.3682***	0.3658***	0.5569***	0.2697***	0.6506***	0.2044*
	(0.0793)	(0.0648)	(0.0936)	(0.0678)	(0.0749)	(0.0903)	(0.0627)	(0.0888)	(0.0885)
Call: sell to open:	0.5151***	0.0483	0.1538	0.3627***	0.3029***	0.4991***	0.1759***	0.6702***	0.3792***
	(0.0804)	(0.0605)	(0.1040)	(0.0617)	(0.0724)	(0.0932)	(0.0533)	(0.0876)	(0.0793)
Call: gamma volume:	-1.0420	-52.8113**	0.1204	1.3859	-3.8713	0.5962	0.0737	4.6244	-1.4402
	(3.5270)	(17.7893)	(3.8230)	(0.9785)	(4.2104)	(1.3449)	(0.2714)	(2.4434)	(1.0802)
Call: open interest:	0.0905**	-0.0902**	0.0358	0.0120	-0.0379**	0.0400*	0.0139	0.0012	0.0262
	(0.0306)	(0.0298)	(0.0271)	(0.0206)	(0.0124)	(0.0170)	(0.0209)	(0.0110)	(0.0186)
Put: total volume:	0.4066***	0.3526***	0.2882***	0.4051***	0.3411***	0.3079***	0.7403***	0.5473***	0.1886**
	(0.0644)	(0.0568)	(0.0660)	(0.0618)	(0.0515)	(0.0645)	(0.0698)	(0.0674)	(0.0701)
Put: buy to close:	0.8390***	0.5107***	0.1708*	0.4185***	0.4801***	0.1456*	0.3178***	0.2618***	-0.1122*
	(0.0945)	(0.0974)	(0.0717)	(0.0882)	(0.0904)	(0.0667)	(0.0711)	(0.0721)	(0.0525)
Put: sell to close:	0.6936***	0.6848***	0.2800**	0.3969***	0.5725***	0.1052*	0.0951	0.2910***	-0.0542
	(0.0897)	(0.0944)	(0.0897)	(0.0830)	(0.0965)	(0.0522)	(0.0563)	(0.0662)	(0.0304)
Put: buy to open:	0.3967***	0.2449**	0.2992***	0.4449***	0.5390***	0.2412***	0.4142***	0.4803***	-0.0310
	(0.0923)	(0.0839)	(0.0854)	(0.0889)	(0.1063)	(0.0616)	(0.0751)	(0.0771)	(0.0396)
Put: sell to open:	0.4372***	0.2364**	0.2126*	0.5692***	0.4582***	0.1034*	0.6263***	0.4880***	-0.1319*
	(0.0876)	(0.0734)	(0.0828)	(0.0942)	(0.0868)	(0.0525)	(0.0781)	(0.0775)	(0.0543)
Put: gamma volume:	-9.1726*	-33.7662**	3.0725	-4.1091	4.0416	0.6606	0.3056	0.9560	0.0290
	(3.8168)	(11.6569)	(2.0437)	(2.7954)	(3.5883)	(0.7473)	(0.3306)	(1.8722)	(0.0987)
Put: open interest:	0.0940***	-0.1021**	-0.0067	0.0209	-0.0476**	0.0300	0.0368*	0.0221*	0.0560
	(0.0193)	(0.0388)	(0.0453)	(0.0157)	(0.0165)	(0.0294)	(0.0186)	(0.0107)	(0.0372)

Figure 8 shows that all groups buy calls in the at-the-money and out-of-the-money categories, but that only small customers buy in-the-money calls around earnings announcements. Figure 10 shows that the desire by small customers to buy in-the-money options is accomodated by firms, large customers, and other small customers. This figure also shows that *selling* calls around the earnings announcement is disproportionately from firms and large customers (who could be hedge funds and thus similar to firms). (In interpreting these figures an important caveat is always that a given option position could be part of strategy.)

For puts, volume increases are also concentrated in at-the-money and out-of-the-money options, with all categories buying options but firms and large customers disproportionately selling.

We also tested to see if volume was related to dispersion among analyst earnings forecasts (see Diether et al., 2002). The hypothesis would be that if option trading is a response to fundamental uncertainty, volume would be greater when market participants were least certain about earnings. The dummy variables interacted with earnings dispersion coefficients (not reported) are generally statistically insignificant and typically negative when significant.

6.2.1 Interest rates

The LIBOR-OIS spread is the difference between the 3-month LIBOR rate and a swap based on the geometric average of the overnight rates for 3 months. This spread increased dramatically during the financial crisis, reflecting distress in the interbank lending market.

Table 9 presents results for the coeffcients on the LIBOR-OIS spread. If we think of a high LIBOR-OIS spread as an indicator of financial distress — specifically, difficulty borrowing — effects should be most pronounced on options with a greater financing component, namely in-the-money options. Indeed, effects are not large, but as the spread increases there is a reduction in trading volume and open interest for in-the-money calls and a slight increase for out-of-the-money calls. Similarly, there is an increase in trading volume for out-of-the-money puts and a reduction for in-the-money puts. High spreads thus do seem to reduce activity for in-the-money options. Note that open interest increases in high strike near- and mid-term puts and calls.

6.3 Short-sale Ban

For a period of several weeks during the financial crisis in 2008, the U.S. enacted a ban on short-selling of over 700 stocks, including virtually all financial firm stocks. The ban was ordered in the early morning of September 19, and was widely considered to have surprised market participants. Moreover, it was not immediately clear whether option market-makers would be exempted from the short-sale ban (early in the following week they were).

A variety of responses to the ban are possible. On the one hand, investors would be expected to buy put options in lieu of the short-sales that were now

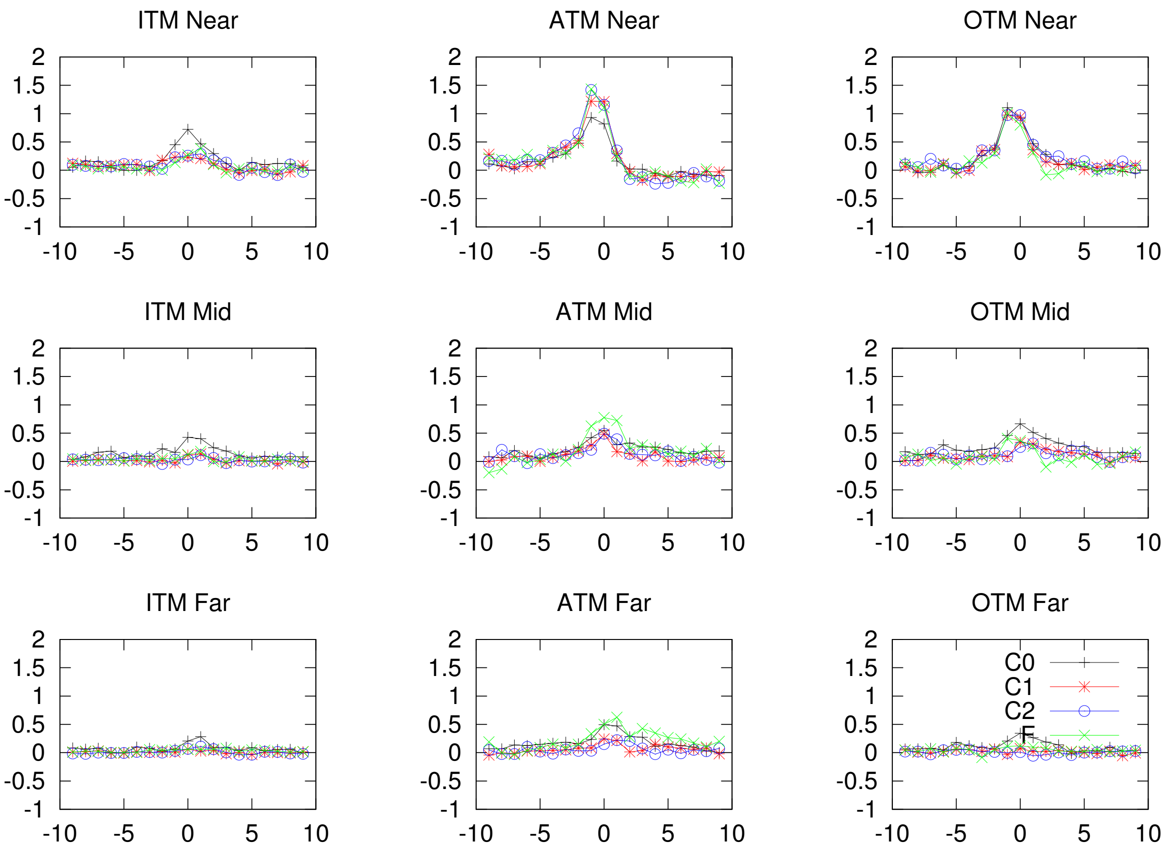


Figure 8: Effect of earnings announcements on call buy volume. Plotted points are regression coefficients for regressions with customer and firm signed as the dependent variables. Dummy variables are from estimates of equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, "CO" means the regression coefficients with customers ordering 1-100 contracts, "C1" is for customers ordering 101-200 contracts, and "C2" is for customers ordering more than 200 contracts. "F" is for firm volume.

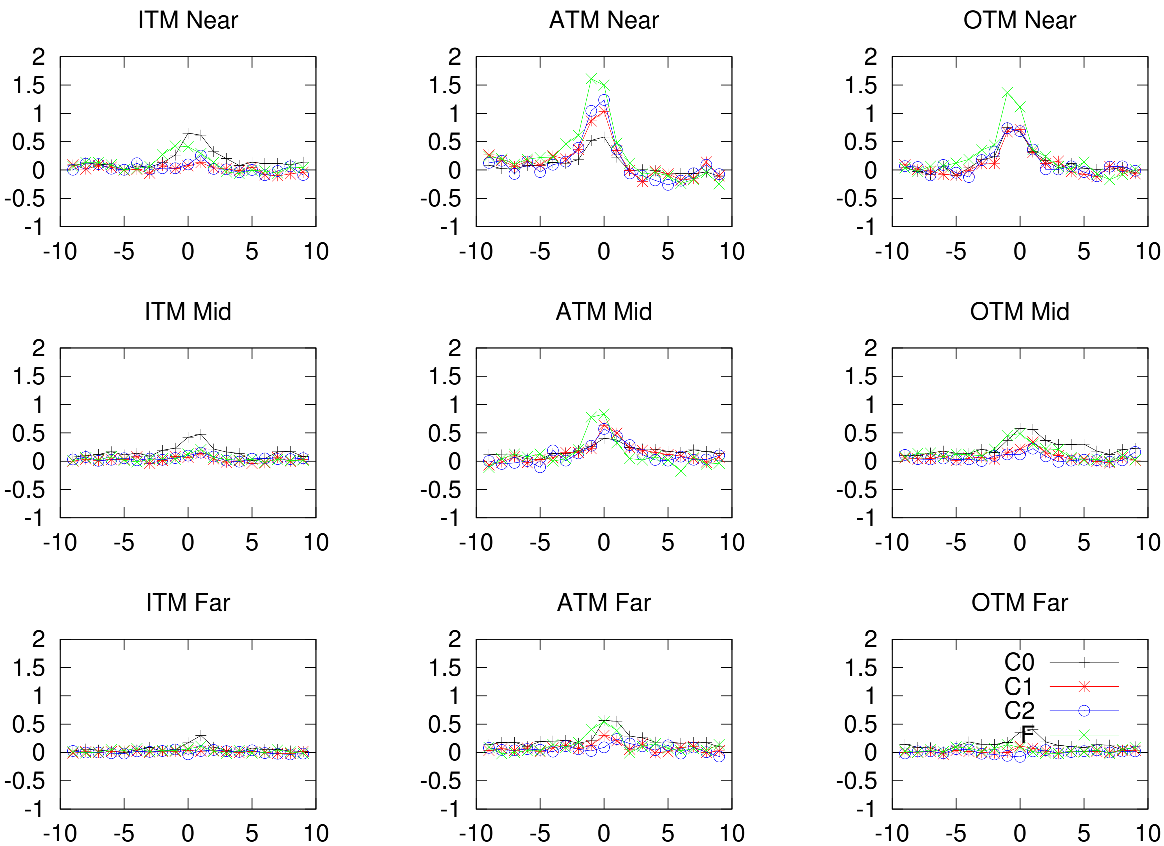


Figure 9: Effect of earnings announcements on call sell volume. Plotted points are regression coefficients for regressions with customer and firm signed as the dependent variables. Dummy variables are from estimates of equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, "CO" means the regression coefficients with customers ordering 1-100 contracts, "C1" is for customers ordering 101-200 contracts, and "C2" is for customers ordering more than 200 contracts. "F" is for firm volume.

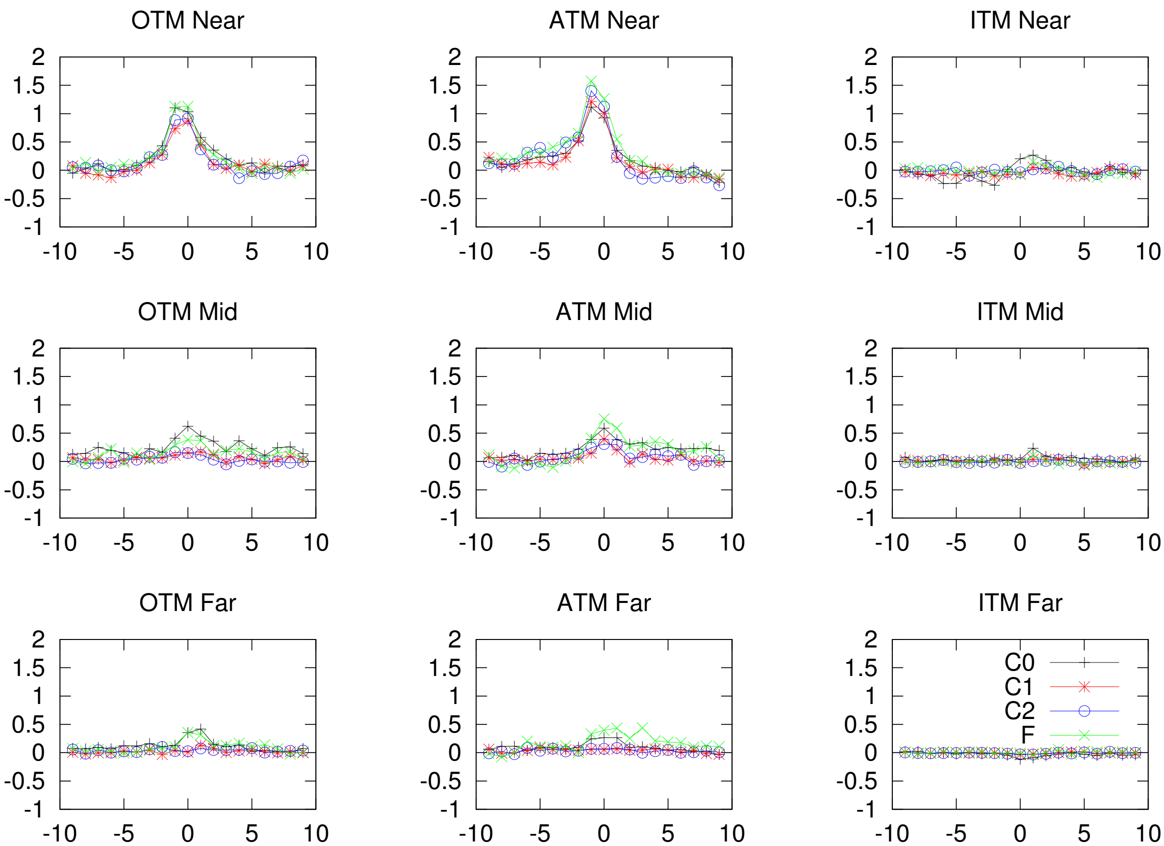


Figure 10: Effect of earnings announcements on put buy volume. Plotted points are regression coefficients for regressions with customer and firm signed as the dependent variables. Dummy variables are from estimates of equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, “CO” means the regression coefficients with customers ordering 1-100 contracts, “C1” is for customers ordering 101-200 contracts, and “C2” is for customers ordering more than 200 contracts. “F” is for firm volume.

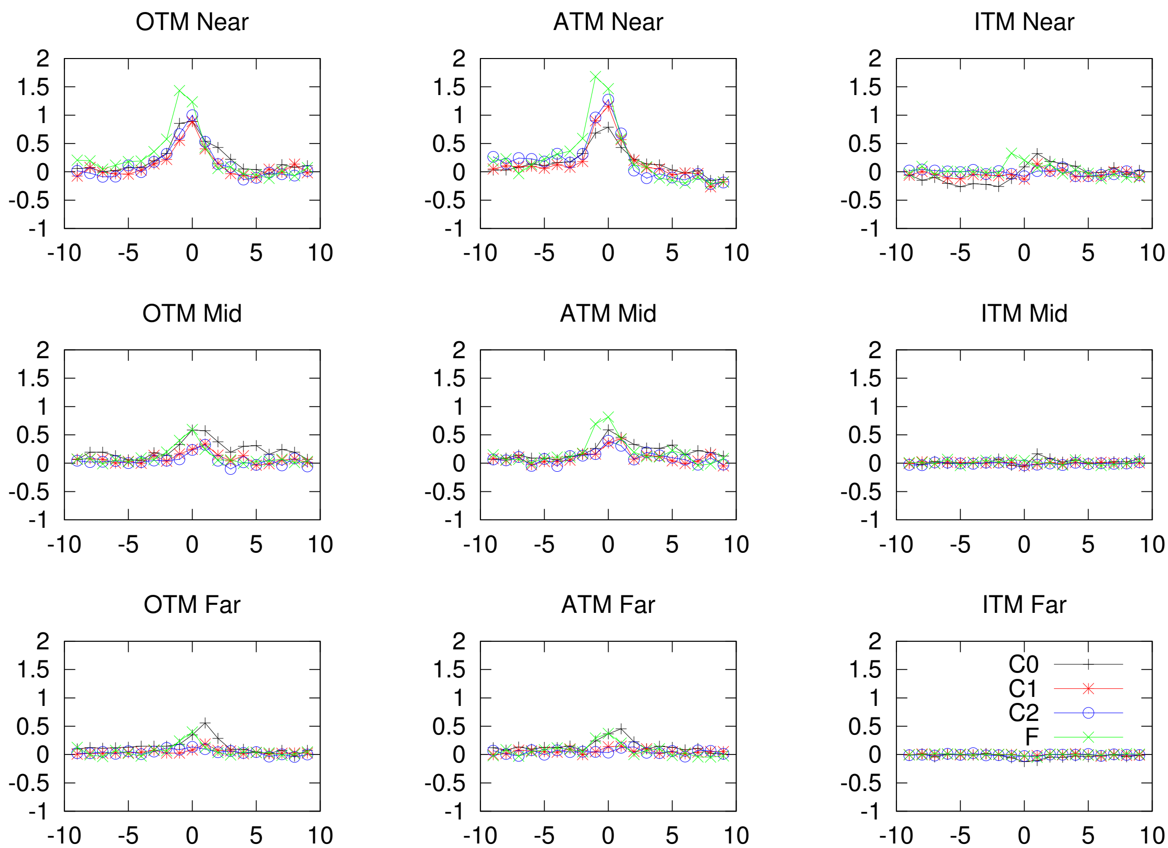


Figure 11: Effect of earnings announcements on put sell volume. Plotted points are regression coefficients for dummy variables from equation (2), with the dummy variables representing the day relative to an earnings announcement (day 0). In the legend, "BO" means a buy to open a position; "SO" means a sale to open a position; "BC" means a buy to close a position; "SC" means a sale to close a position; "TV" means total volume in that category of options.

Table 8: LIBOR-OIS spread. The table reports 126 coefficients on the LIBOR-OIS spread from estimates of equation (2). Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	-0.2791***	-0.0324	0.0624*	0.0979**	-0.0252	0.0674*	-0.0254	-0.2715***	-0.3743***
	(0.0331)	(0.0219)	(0.0282)	(0.0320)	(0.0216)	(0.0322)	(0.0367)	(0.0311)	(0.0391)
Call: buy to close:	-0.1515***	0.1055**	0.2121***	-0.0505*	-0.0265	0.1482**	-0.0344	-0.1952***	-0.1050**
	(0.0376)	(0.0341)	(0.0408)	(0.0231)	(0.0350)	(0.0509)	(0.0209)	(0.0385)	(0.0354)
Call: sell to close:	-0.2822***	-0.0276	0.0943	-0.1243***	-0.0161	0.2810***	-0.0535*	-0.2056***	-0.0781*
	(0.0452)	(0.0387)	(0.0489)	(0.0334)	(0.0389)	(0.0468)	(0.0269)	(0.0406)	(0.0307)
Call: buy to open:	-0.1652***	0.0906**	0.0261	-0.0586	-0.0350	-0.0453	-0.0110	-0.2860***	-0.1858***
	(0.0484)	(0.0331)	(0.0435)	(0.0356)	(0.0394)	(0.0527)	(0.0342)	(0.0455)	(0.0412)
Call: sell to open:	-0.1337***	0.0451	0.1097**	-0.0629*	-0.2907***	-0.1551**	-0.0007	-0.5021***	-0.2785***
	(0.0383)	(0.0311)	(0.0407)	(0.0253)	(0.0378)	(0.0538)	(0.0249)	(0.0479)	(0.0435)
Call: gamma volume:	1.3694	9.2001	-0.0366	0.2718	2.2100	-0.5368	-0.1699	0.3220	-0.2732
	(0.7831)	(4.9333)	(1.2016)	(0.2278)	(1.7281)	(0.5288)	(0.1206)	(0.5541)	(0.1783)
Call: open interest:	-0.2065***	-0.0474***	0.0315***	-0.0407***	0.0157***	0.1176***	-0.1058***	-0.0407***	-0.0367***
	(0.0118)	(0.0074)	(0.0047)	(0.0091)	(0.0046)	(0.0047)	(0.0082)	(0.0052)	(0.0054)
Put: total volume:	0.1951***	-0.0595*	-0.1427***	0.1756***	0.0144	0.1327**	-0.2986***	-0.2221***	-0.0684
	(0.0282)	(0.0235)	(0.0371)	(0.0303)	(0.0242)	(0.0450)	(0.0461)	(0.0366)	(0.0364)
Put: buy to close:	0.1943***	0.0552	0.0358	0.1805***	0.2589***	0.3960***	-0.0233	0.0430	0.0491*
	(0.0422)	(0.0360)	(0.0331)	(0.0350)	(0.0399)	(0.0401)	(0.0239)	(0.0311)	(0.0235)
Put: sell to close:	0.2280***	0.0781	-0.0621	0.2241***	0.1333**	0.1478***	-0.0239	-0.0379	-0.0085
	(0.0443)	(0.0427)	(0.0357)	(0.0342)	(0.0445)	(0.0316)	(0.0206)	(0.0247)	(0.0131)
Put: buy to open:	0.3509***	0.0839*	-0.2477***	0.2780***	-0.0327	0.0845**	-0.1252***	-0.2643***	-0.0326
	(0.0495)	(0.0385)	(0.0387)	(0.0431)	(0.0470)	(0.0326)	(0.0344)	(0.0339)	(0.0221)
Put: sell to open:	0.3175***	-0.0458	-0.2420***	0.0785	-0.0777	0.0899**	-0.1394***	-0.1138**	-0.0283
	(0.0475)	(0.0357)	(0.0379)	(0.0405)	(0.0420)	(0.0320)	(0.0392)	(0.0399)	(0.0259)
Put: gamma volume:	-2.2663*	-2.6148	-0.3672	0.5921	-0.6279	0.3417*	0.1697	-0.4534	0.0144
	(0.8964)	(3.2868)	(0.4753)	(0.3166)	(1.2616)	(0.1735)	(0.1884)	(0.2911)	(0.0312)
Put: open interest:	-0.1048***	0.0130	0.0727***	-0.0269***	0.0580***	0.1911***	-0.1191***	-0.0402***	-0.0281**
	(0.0079)	(0.0067)	(0.0085)	(0.0074)	(0.0049)	(0.0087)	(0.0089)	(0.0053)	(0.0109)

forbidden. On the other hand, if market-makers believed themselves unable to short shares to hedge, they would likely be unwilling to sell puts.

Table 9 presents the dummy coefficients for September 19. Focusing on puts, the prominent coefficient is an economically large decline in open interest for in-the-money puts. The coefficient of -1.47 suggests a decline in open interest of almost 80%. In-the-money puts would have the highest delta in absolute value and thus be the hardest to hedge in the face of a ban on short sales. Both buys and sells to close in-the-money put positions also declined significantly, consistent with less trading in puts.[9] At the same time, open interest in in-the-money calls increased.

In interpreting these results, it is important to keep in mind that September 19 was special in at least two iportant respects. First, there was of course widespread concern about the stability of the financial system; for example, the Treasury announced on that day insurance for money-market funds. This alone could lead to abnormal trading patterns. Second, September 19 was an expiration Friday. The regression specification includes a dummy variable for expiration, so any effects should be interpreted as above and beyond what would normally be experienced at expiration. In sum, the results are at least consistent with supply effects stemming from the market-makers being unable or unwilling to short stocks.

6.4 Dividends

Pool et al. (2008) demonstrate that volume for in-the-money calls increases significantly on the day before the ex-dividend date.[10] They attribute this to proprietary traders who exploit the failure of individual option buyers to exercise. Specifically, proprietary traders buy large numbers of in-the-money calls and sell equal numbers of higher-strike in-the-money calls They then exercise all purchased calls. Written calls are assigned randomly against the exercised calls. The proprietary traders then hope that some of the written calls will not be assigned because some investors don't exercise. When the stock price drops ex-dividend, the unassigned written calls make money.

We confirm the findings of Pool et al. (2008). In our regressions, the dividend date dummy in the total volume regression is 2.43, which represents an *11-fold* volume increase. There is also a slight increase in volume (approximately doubling) for mid and far-term in the money calls, but little for puts and other call categories. In the open/close data, there are positive coefficients on both purchases and sales. There is no change in open interest, which reflects the optimal exercise of the large number of newly-purchased calls. The analysis in Pool et al. (2008) is thorough, so we take these results as a check of the reasonableness of our procedure.

[9] The categorization of options is based on the prior day's delta, so the fact that the market went up on September 19 would not mechanically change the assignment of an option to a moneyness category.

[10] Because settlement three days after the trade, the ex-dividend date is three days before the date on which owners of record receive the dividend.

Table 9: Announcement date of short-sale ban. The table reports 126 coefficients on a dummy variable for September 19, 2008, from estimates of equation (2). Row labels report the nature of the dependent variable and column labels the particular bucket. Standard errors are also reported, and explanatory variables are those in Section 4.

	M1near	M2near	M3near	M1mid	M2mid	M3mid	M1far	M2far	M3far
Call: total volume:	-0.2789	-0.5616**	0.8825***	0.8774*	0.1711	0.2411	0.2850	-0.1044	-0.1250
	(0.3229)	(0.2040)	(0.2344)	(0.4391)	(0.1426)	(0.2265)	(0.2455)	(0.3777)	(0.3243)
Call: buy to close:	0.8982	0.0788	0.4652	1.1025	0.7512*	0.4902	0.0806	0.7153	0.1287
	(0.5337)	(0.3695)	(0.4028)	(0.6061)	(0.3355)	(0.4037)	(0.3801)	(0.3681)	(0.4066)
Call: sell to close:	-0.1225	0.0717	1.1592*	1.8997***	0.9978**	0.8362*	0.8822*	0.5202	-0.1708
	(0.5807)	(0.3688)	(0.5523)	(0.4923)	(0.3845)	(0.3707)	(0.3662)	(0.3693)	(0.3891)
Call: buy to open:	0.5082	-0.4621	0.9862*	-0.2222	0.1258	0.7016	0.0278	0.2039	0.1354
	(0.4989)	(0.2902)	(0.4272)	(0.4662)	(0.2856)	(0.4078)	(0.3057)	(0.3436)	(0.3680)
Call: sell to open:	0.0176	-0.5873*	1.1570**	-0.1253	0.1681	0.6802	0.0026	0.2312	0.1112
	(0.4271)	(0.2819)	(0.3691)	(0.4401)	(0.3286)	(0.4160)	(0.3092)	(0.4352)	(0.3786)
Call: gamma volume:	19.2213	-9.5801	-18.5509	8.6571	-31.5047	-13.5214	-2.3614*	-4.2109	2.4554
	(23.6024)	(54.3750)	(49.3969)	(11.2903)	(35.2108)	(13.1767)	(1.1161)	(7.3476)	(3.3641)
Call: open interest:	0.9434***	0.1665	-0.5350**	0.5058***	0.1167	-0.1975*	0.1140	0.0103	-0.1023
	(0.1981)	(0.1245)	(0.1670)	(0.1397)	(0.2010)	(0.0922)	(0.1149)	(0.0541)	(0.0788)
Put: total volume:	-0.3172	-0.4387*	-1.1815**	-0.4768	-0.2268	0.3338	-0.3130	-0.4004	0.5409
	(0.1742)	(0.2054)	(0.4576)	(0.4249)	(0.2439)	(0.3682)	(0.4203)	(0.4090)	(0.5883)
Put: buy to close:	0.3838	-0.6527	-1.5559**	-0.1483	-0.5062	0.4935	0.6090	-0.5787	-0.3931
	(0.4034)	(0.4038)	(0.5558)	(0.3820)	(0.4858)	(0.3719)	(0.3908)	(0.3396)	(0.6133)
Put: sell to close:	-0.5605	-0.9125**	-1.5721*	-0.1021	-0.9539**	-0.0338	0.5038	-0.1556	0.2860
	(0.3501)	(0.3237)	(0.6762)	(0.4390)	(0.3274)	(0.6598)	(0.4156)	(0.3017)	(0.5438)
Put: buy to open:	-1.5666**	0.4196	-0.4075	-0.9996*	-0.5224	0.6928	-0.1235	-0.3961	0.5053
	(0.5217)	(0.3667)	(0.7420)	(0.4953)	(0.5575)	(0.5094)	(0.3846)	(0.3512)	(0.6781)
Put: sell to open:	-0.8163	-0.7236*	-0.1993	-0.5076	-0.9438	0.5345	-0.5498	-0.9525*	0.3525
	(0.4865)	(0.3520)	(0.7558)	(0.5688)	(0.5913)	(0.5297)	(0.3343)	(0.4278)	(0.5587)
Put: gamma volume:	-15.2865	122.1634*	20.9454	2.0352	32.3285	-2.9463	2.3429	2.7342	-0.7148
	(18.0587)	(50.8028)	(27.7854)	(5.9651)	(26.9239)	(3.2583)	(1.2127)	(2.7785)	(0.4356)
Put: open interest:	0.3502**	-0.2205	-1.4737***	0.2666**	-0.1512	-0.2033	0.4566	-0.1266	-0.5179
	(0.1157)	(0.1868)	(0.4146)	(0.0991)	(0.1885)	(0.1731)	(0.2995)	(0.1429)	(0.3863)

7 Conclusions

Options provide investors a bundle of economic attributes that differ from the stock. We examine the economic determinants of option trading and find that most option trading is in short-term at-the-money and out-of-the-money options, where exposure to gamma and jump risk is greatest. There is less trading in in-the-money options, where options provide an opportunity to obtain a pure leveraged position and the option is most clearly an alternative to holding the stock. There is also substantially less volume in long-term options, although the ratio of open interest to volume is greater for long-term options, suggesting that long-term option buyer or sellers intend to hold their positions.

The factors that affect option trading include stock volume and earnings announcements. We find that volume elasticities are approximately one, and that open interest increases as well during high volume days, though by substantially less than the volume increase. Trading around earnings announcements is most pronounced in at-the-money and out-of-the-money options, both calls and puts. There is a large increase in volume and in gamma volume, but not in open interest, suggesting that market-makers absorb some of this volume increase. Volume broken down by customer category shows that small customers behave differently than large customers and firms, buying more in-the-money options and selling fewer options, suggesting that during earning announcement periods, the large and professional traders provide options to small investors.

Changes in the LIBOR-OIS spread also affected option trading. Increases in the spread, which were interpreted as a sign of distress during the crisis, are associated with volume and open interest reductions in in-the-money puts and calls, which are options that implicitly have significant financing.

Finally, we find evidence that the short-sale ban on September 19, 2008 could have reduced open interest in in-the-money puts. The evidence is at best suggestive, however, given the complicated events of that period.

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