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Failure to exercise call options: An anomaly and a trading game☆

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Abstract

In the US, exchange-traded options are unprotected from cash dividend payments on the underlying stock. Consequently, it may become optimal to exercise deep in-the-money call options just prior to the ex-dividend day. In this study, we examine the extent to which option holders fail to exercise their call options on the day prior to an ex-dividend day when it is optimal to do so. Using a sample of call options on stocks with quarterly dividends of at least a penny per share during the period January 1996 through April 2006, we find that more than half of outstanding long positions go unexercised. We estimate that this failure to exercise has caused call option holders to lose over $491 million over a ten-year period. We also show how market makers capture the lion's share of the proceeds by using a dividend spread trading strategy.

JEL Classifications: G13; G14; G10

Keywords: Ex-dividend; Call option exercise; Dividend spread

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0. Introduction

In the US, exchange-traded options are ‘‘unprotected’’ from cash dividend payments on the underlying stock.[1] On the ex-dividend day, the stock price falls by the amount of the dividend with no commensurate reduction in the exercise price of the option. Consequently, it often becomes optimal to exercise deep in-the-money call options just prior to the ex-dividend date in order to receive the dividend and at the cost of foregoing the remaining time value of the option. In this study, we examine the extent to which option holders fail to exercise their call options when it is optimal to do so. Using a sample of call options on stocks with quarterly dividends of at least a penny per share during the period January 1996 through April 2006, we find that more than half of outstanding long positions remain unexercised and estimate that this failure to exercise has caused call option holders to lose (forego profits of) over $491 million.

Exactly why many call option holders fail to exercise when they should is unclear. Trading costs, monitoring costs, and trader irrationality all may play roles. Independent of the reason, however, the failures to exercise have not gone unnoticed by trading professionals who systematically collect the foregone profits by gaming the clearinghouse's exercise allocation algorithm. The trading strategy, called ‘‘dividend spread arbitrage,’’ involves simultaneously buying and selling a large number of contracts in a particular in-the-money call option series on the day before ex-dividend. Since the long and short position are in exactly the same contract, the position has no risk. Later in the day, the arbitrager exercises the entire long call position, as he should, and then waits to be assigned shares of stock on the short call position. If the short call position is not fully assigned because some call option holders fail to exercise, part of the arbitrager's short call position experiences a windfall gain when the stock goes ex-dividend and the call drops in value. We explore the degree to which this trading game is played and by whom, as well as the degree to which normal trading activity is disrupted. The trading disruption gives rise to a discussion of whether such information-less trading should be limited.

The structure of the paper is as follows. In Section 1, we review the literature on irrational exercise. In Section 2, we specify the conditions for early exercise of American call options and show how the failure to exercise is reflected in open interest. Section 3 contains a description of the sources of data used in our investigation of exercise behavior during the sample period January 1996–April 2006. Section 4 contains an analysis of the degree to which call holders fail to exercise optimally on ex-dividend events. We also estimate the amount of money ‘‘left on the table’’ by their failure to exercise. In Section 5, we examine in detail the dividend spread arbitrage trading activity and show how it can result in extraordinarily large call option trading volume. Indeed, in recent years, it is not

[1]In the event of extraordinarily large special cash dividend distributions (i.e., 10% of the prevailing stock price), however, the Options Clearing Corporation (OCC) ‘‘protects’’ the value of option contracts by adjusting the exercise prices of outstanding option series downward by the amount of the cash dividend payment. On July 20, 2004, for example, Microsoft Corporation (‘‘MSFT’’) announced a special cash dividend of $3 per share. At the time, the MSFT share price closed at $28.32, so the distribution amounted to 10.6% of the prevailing share price. On November 9, 2004, Microsoft shareholders approved a $3 special cash dividend payable on December 2, 2004, to shareholders of record on November 17, 2004. As of November 15, 2004 (i.e., the ex-dividend date of Microsoft's shares), therefore, the exercise prices of all MSFT option series were reduced by $3. The OCC is planning to adjust strike prices for all special dividends over $0.125 per share, but strike prices are not adjusted for regular dividends.

uncommon for call option trading volume to exceed volume of trading in the underlying stock on the days before ex-dividend. We also show that the incremental trading volume on those days is closely associated with the exercise behavior of the arbitragers and that market makers are by far the most active dividend spread traders, followed by member firms. In Section 6, we discuss some of the policy issues raised by the failure to exercise and the subsequent arbitrage activity. Section 7 contains a brief summary and the main conclusions.

1. Prior evidence on irrational exercise decisions

Irrational exercise of American-style options has been examined empirically in a number of studies.[2] In the stock option market, Kalay and Subrahmanyam (1984) examine the price behavior of call options written on 189 dividend-paying stocks during the period April 1979–June 1980 and find significantly negative excess returns for in-the-money call options on ex-dividend days (i.e., the close on the day before to the close on the day of ex-dividend). While this evidence, on first appearance, suggests that some option holders have irrationally failed to exercise, such a conclusion is unwarranted unless the transaction costs and risks of implementing a trading strategy to capture the gains are explicitly considered. In an attempt to assess whether the exercise behavior is irrational, Castanias, Chung, and Johnson (1988) simulate the profitability of a dividend spread trading strategy using price data for highly active call options during the period January 1982–May 1986. Specifically, their strategy involves buying one deep in-the-money call option on the day before ex-dividend day and selling another deep in-the-money call option at a different exercise price but with the same time to expiration. Since the options are deep in-the-money, their deltas are equal to one and the position is risk-free. Unfortunately, they do not have access to bid/ask price quote data, so they cannot measure after-transaction-cost profitability. They argue that the documented profitability using last trade prices is small and conclude that the observed failure to exercise is rational. In a recent working paper, Hao, Kalay, and Mayhew (2006) identify the dividend spread arbitrage and examine the implications for options volume around ex-dividend days in the year 2003.

Overdahl and Martin (1994) examine the rationality of exercise for a sample of 7,098 put and call series written on 54 common stocks in the period July 1990 to March 1991. They find that option exercise does not occur in precise accordance with theory, but conclude, with respect to ex-dividend behavior, that the number of calls that failed to be exercised was small. Poteshman and Serbin (2003), focusing on days other than ex-dividend days, document significant numbers of irrational early call option exercises, particularly for customers of discount and full-service brokers. At the same time, traders at large investment houses exhibit no irrational early exercise behavior. Similarly, Finucane (1997) documents irrational early exercise of CBOE call options during the period 1996–1999.

[2]The early exercise literature summarized here focuses on American-style options traded on exchanges. A variety of other examples also exist. Executive stock options are one. Heath, Huddart, and Lang (1999) document the early exercise behavior for executive stock options and find that it is related to recent advances in the underlying stock price. Residential mortgages are another. Mortgages often contain a prepayment option that permits the homeowner to pay the remaining balance of the mortgage when interest rates fall. There is a large literature that shows that homeowners often fail to exercise their prepayment option when they should. See, for example, Stanton (1995). Convertible securities are yet another. Dunn and Eades (1989), among others, document that convertible bond holders often fail to convert their bond into shares of stock when it is optimal to do so.

In contrast to this prior research, our analysis focuses on ex-dividend days and finds evidence of a failure to exercise when exercise is optimal.

Early exercise behavior has also been examined for options on other underlying instruments such as stock indexes and futures contracts. Diz and Finucane (1993), for example, conduct a comprehensive empirical analysis of the rationality of early exercise decisions in the S&P 100 index option market during the period April 1983 through December 1988. They show that many exercise decisions are inefficient in the sense that they occur when recorded bids are greater than exercise values. While other market imperfections (e.g., the wildcard option embedded in the S&P 100 contract) account for some of the documented inefficiencies, they conclude that some exercise behavior is ‘‘clearly irrational.’’ Gay, Kolb, and Yung (1989), for example, examine the exercise of T-bond futures options traded on the Chicago Board of Trade during the period May 1984–November 1986. Like stock options in the US, futures options are American-style. And, since the futures position involves no investment outlay, both call and put options may optimally be exercised early. Using the Barone-Adesi and Whaley (1987) quadratic approximation to value futures options, they document numerous failures to exercise as well as some exercises that should not have occurred. Gay, Kolb, and Yung (1989) conclude that exercise behavior is generally rational. Overdahl (1988) performs a similar experiment using T-bond futures options.

2. Early exercise of call options on stocks

To assess whether failure to exercise a call option is irrational, one must specify rational exercise behavior. In Section 2.1, we specify the early exercise conditions around ex-dividend days. In Section 2.2, we specify how failure to exercise is detected. In Section 2.3, we examine the consequences of the failure by some traders to exercise, including the trading game that has arisen.

2.1. Conditions for early exercise

In the US, exchange-traded call options on individual stocks are American-style. In the event that the stock pays no dividends during the option's life, Merton (1973) shows that the call will never be optimally exercised before expiration. The reason is that the option holder prefers to defer the cash payment of the exercise price until expiration, thereby earning interest income. When the stock pays a cash dividend during the option's life, however, the option holder must weigh the amount of the cash dividend which can be captured by exercising the call before ex-dividend against the value of the option should it remain unexercised.

A call option holder's exercise decision can be framed in a number of ways. We will discuss two. The first is a *model-based approach*. The key distinction of this approach is that it requires a specific option valuation model. For illustrative purposes, we will use the Black-Scholes (1973)/Merton (1973) option valuation framework.[3] Assuming the stock pays no dividends during the option's life, the value of an American-style call option is

[3]This model assumes that the stock price follows geometric Brownian motion and that a risk-free hedge may be formed between the call and its underlying stock. The valuation of American-style call options on stocks under the Black-Scholes/Merton assumptions is provided in Roll (1977), Geske (1979), and Whaley (1981).

given by the "Black-Scholes formula,"

$$C(S,X,T) = SN(d_1) - Xe^{-rT}N(d_2), \tag{1}$$

where

$$d_1 = \frac{\ln\left(Se^{rT}/X\right) + .5\sigma^2 T}{\sigma\sqrt{T}} \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{T},$$

S and σ are the price and the volatility rate of the underlying stock, X and T are the exercise price and time to expiration of the option, r is the risk-free rate corresponding to the time to expiration of the option, and $N(d)$ is the cumulative univariate normal density function with upper integral limit d.

To understand the American-style call option holder's dilemma if a dividend is paid, assume he is standing in time the instant prior to ex-dividend. If he exercises the call immediately, he receives exercise proceeds $S - X = S^x + D - X$, where $S^x \equiv S - D$ is the ex-dividend stock price,[4] and D is the amount of the cash dividend. If he does not exercise the call, the stock price drops by the amount of the dividend, and the ex-dividend call option value is $C(S^x, X, T)$. Thus, the call option holder's decision just prior to ex-dividend weighs the exercise proceeds of exercise against the value of the call if left unexercised:

$$(S - X) - C(S^x, X, T). \tag{2}$$

If $(S - X) < C(S^x, X, T)$, the call should be left unexercised since it is worth more alive than dead. On the other hand, if $(S - X) > C(S^x, X, T)$, the call should be exercised immediately. If it is not, the option holder experiences a windfall loss equal to $(S - X) - C(S^x, X, T)$. Since we know the structural model for valuing the call (i.e., Eq. (1)), it is straightforward to show that the likelihood of early exercise increases (a) the higher is the dividend, (b) the higher is the stock price, (c) the lower is the exercise price, (d) the shorter is the time remaining to expiration, (e) the lower is the volatility rate, and (f) the lower is the risk-free interest rate. Holding time to expiration constant, we can also use the Black-Scholes formula to identify the critical exercise price below which all call option series should be exercised by solving

$$S - X^* = C(S^x, X^*, T). \tag{3}$$

Using the *model-based* critical exercise price to determine which option series should be exercised early has certain limitations. First, it requires a valuation model. Second, it requires that we estimate the amount and timing of all expected dividend payments during the option's life as well as the expected future volatility rate. While we use the model-based approach in the empirical tests that follow, a *market-based approach* is, in principle, also available. Such an approach would simply compute the difference between the observed market price of the call option and the exercise proceeds of the option,

$$C - (S - X), \tag{4}$$

[4]The stock price is assumed to fall by the amount of the dividend at the ex-dividend instant. This proposition has been investigated empirically in a number of academic studies including Campbell and Beranek (1955), Durand and May (1960), Elton and Gruber (1970), Kalay (1982), and Michaely (1991). Barone-Adesi and Whaley (1986) use the prices of call options on dividend-paying stocks to infer the ex-dividend stock price decline.

at the close of trading on the day before the ex-dividend day. If this quantity equals 0, the call should be exercised immediately since the market says it has no remaining time value. If this quantity is greater than 0, the call should not be exercised since the market says that the call value is greater than its cum-dividend exercise proceeds. Implementing this approach is not without problems, however. One issue is what prices to use. Should C and S be based on bid/ask midpoints, or should they be based on ask and bid prices, respectively? Another issue is price discreteness. Option prices less than \$3, for example, are quoted to the nearest 5-cent increment, and those with prices greater than \$3 are quoted to the nearest 10-cent increment. Consequently, it is highly unlikely that (4) will ever be exactly equal to 0.

2.2. Detection of failure to exercise

Interestingly enough, although the rules for deciding whether to exercise a call on the day before ex-dividend are as simple as (2) or (4), a goodly number of long in-the-money call options remain open at the time of ex-dividend. The direct measure of unexercised options is, of course, the contract's open interest at the close of trading on the day before ex-dividend. Open interest is the number of outstanding option contracts reported at the end of each day and may be calculated from the buy-side (i.e., long positions) or the sell-side (i.e., short positions). From the buy-side perspective, the relation between open interest on the day before ex-dividend, OI_{t-1}, and open interest two days before ex-dividend, OI_{t-2}, is given by

$$OI_{t-1} = OI_{t-2} + OB_{t-1} - CS_{t-1} - E_{t-1}, \quad (5)$$

where OB_{t-1} is opening buys on the day before ex-dividend, CS_{t-1} is closing sales, and E_{t-1} is the number of long positions exercised. From a supply-side perspective, it is

$$OI_{t-1} = OI_{t-2} + OS_{t-1} - CB_{t-1} - A_{t-1}, \quad (6)$$

where OS_{t-1} is opening sales on the day before ex-dividend, CB_{t-1} is closing buys, and A_{t-1} is the number of assigned short positions.

For options that should be exercised on day *t-1*, open interest at the end of day *t-1* should be zero ($OI_{t-1} = 0.0$). From (5), exercises at the end of day *t-1* are then given as $E_{t-1} = OI_{t-2} + OB_{t-1} - CS_{t-1}$ for call options that are optimally exercised on the day before ex-dividend. If the number of opening buys equals the number of closing sells on day $t-1$, the number of exercises should be equal to the previous day's open interest. Any open interest remaining on day $t-1$ are unexercised options. The ratio, OI_{t-1}/OI_{t-2}, is the proportion of contracts outstanding that call option holders do not exercise.

To illustrate the open interest computation mechanics together with actual exercise behavior, consider Table 1. The mechanics are demonstrated from the buy-side's perspective. At the close on day $t-2$, the open interest is 4,000 contracts. The call option is assumed to be deep in the money and should optimally be exercised on the day before ex-dividend. The difference between the exercise proceeds just prior to ex-dividend and the value of the call should it go unexercised is assumed to be $(S-X) - C(S^x, X, T) = .40$, which is shown in the second to last column of the table. In other words, if the call option holder does not exercise, \$.40 per share is lost. In scenarios A and B only retail customers are in the market, and no additional open interest

Table 1
Hypothetical call option trading/exercise behavior in the days preceding an ex-dividend day

Scenarios	Two days before ex-dividend day (t–2)	Day before ex-dividend day ($t-1$)							
	Closing open interest	New Positions	Contracts available to exercise	Number exercised	Probability of short position being assigned	Number of assignments	Number not assigned	Gain per share	Total gain on unassigned positions
Rational exercise behavior									
A. No arbitrage activity	4,000	0	4,000	4,000	1	4,000	0	0.40	0
Actual exercise behavior									
B. No arbitrage activity									
	4,000	0	4,000	2,000	0.50	2,000	2,000	0.40	80,000
C. With arbitrage activity									
Customers	4,000	0	4,000	2,000		3,600	400	0.40	16,000
Arbitragers	0	16,000	16,000	16,000		14,400	1,600	0.40	64,000
	4,000	16,000	20,000	18,000	0.90	18,000	2,000		80,000
D. With arbitrage activity									
Customers	4,000	0	4,000	2,000		3,960	40	0.40	1,600
Arbitragers	0	196,000	196,000	196,000		194,040	1,960	0.40	78,400
	4,000	196,000	200,000	198,000	0.99	198,000	2,000		80,000

is assumed to be established (i.e., $OB_{t-1} - CS_{t-1} = 0$).[5] Under rational exercise behavior (Scenario A), all call option holders exercise (i.e., the number of exercises equals 4,000) and the open interest falls to 0. Since all options are exercised, the probability that someone short the option is assigned is 1, and the number of assignments is 4,000 contracts. The closing open interest on the day before ex-dividend is 0 in this case. Under actual exercise behavior, however, not all long positions are exercised. Under Scenario B, 2,000 of the 4,000 open call option contracts are exercised, so that 2,000 contracts remain open. Under clearinghouse procedures, exercises are assigned randomly to open short positions. Hence in this example, the probability that someone short the option is assigned is .5. For the 2,000 short positions remaining open, there is a \$.40 per contract windfall gain when the option price falls on the ex-dividend day. The total dollar value forfeited by long call option holders to the shorts is \$.40 $\times$ 2,000 $\times$ 100 or \$80,000.

2.3. *The trading game*

Open interest for in-the-money call options often remains positive at the close of trading on the day before ex-dividend. The reasons for this are unclear. One possibility is that call option holders are irrational or fail to understand the effect of the dividend on the option price. Another is that, while they may understand the effect, they do not want to bear the expense of monitoring the firm's dividend payout information. Yet another is that transaction costs impede the profitability of exercise. To exercise the call option, the call option holder pays a commission. In addition, he pays a second commission and half the bid/ask spread when he sells the stock received pursuant to exercise. Alternatively, the call option holder can choose to reverse his position in the option market; however, this is unlikely since trading costs in the option market are higher than in the stock market. Whatever the reasons, the fact of the matter is that many call option positions that should be exercised early are not, and that gives rise to a profit opportunity.

In the instances where the call option is not exercised when it should be, the call option holder implicitly forfeits $(S - X) - C(S^x, X, T)$ to *a* call option seller. Exactly who receives the gain is determined by chance. When a call is exercised, the Option Clearing Corporation (OCC) randomly assigns the exercise obligation to someone who is short the call.[6] This individual delivers the stock and receives a cash payment in the amount of the exercise price. If not all call option holders exercise, some lucky individuals who are short the call will not be assigned the obligation to deliver and will implicitly earn the difference between the exercise proceeds and the value of the call at the open on the ex-dividend day.

The empirical fact that not all call option holders exercise their calls prior to the ex-dividend instant when it is optimal to do so has not gone unnoticed by the marketplace. Indeed, it has given rise to a trading game called dividend spread arbitrage. In a dividend

[5]Since deep in-the-money calls have relatively large bid/ask spreads, this assumption is reasonable. Absent the option/dividend play, no new long positions will be opened only to be exercised at the end of the day. Conversely, no existing long positions will be covered by sales as trading costs in the stock market are lower than in the option market.

[6]Under OCC rules, call option holders must tender their exercise notice for stock options by 8PM (EST). On the short side, the OCC assigns to short call holders obligations to deliver stock by about 1AM.

spread arbitrage, the trader simultaneously buys and sells a large number of deep in-the-money calls,[7] where both sides of the trade are opening transactions, (i.e., $OB_{t-1}>0,\quad OS_{t-1}>0$ while $CS_{t-1}=0,\quad CB_{t-1}=0$).[8] This is illustrated in Scenario C of Table 1, where an arbitrager simultaneously buys and sells 16,000 in-the-money calls. Thus, the number of contracts available for exercise is the original 4,000 contracts from natural investors plus the 16,000 newly established long positions, a total of 20,000. At the end of the day, the arbitrager exercises his entire long call position to take delivery of $16,000\times 100=1,600,000$ shares of stock, and then waits to determine the fate of his short position. In the event that all call option holders exercise as they should, the arbitrager is assigned the obligation to make delivery of 1,600,000 shares of stock, leaving a net position of zero. In the event that some call option holders do not exercise, the arbitrager experiences a windfall gain.

As in Scenario B, however, the customers in Scenario C are assumed to exercise only 2,000 of their 4,000 outstanding contracts. This means that \$80,000 is being left on the table. In the absence of arbitrage activity, the \$80,000 is earned by customers. When the arbitrage activity is considered, however, the customers earn only \$16,000. To see why, consider the remaining table entries under Scenario C. On the day before ex-dividend, the arbitragers' new positions bring the total number of contracts available for exercise to 20,000 contracts. The arbitragers exercise all 16,000 contracts of their long call position, and, as in Scenario B, customers exercise 2,000 contracts. This brings the total number of exercises to 18,000. Under the random assignment procedure of the OCC, the likelihood of a short call's being assigned is 18,000/20,000 or .9. Since customers are short 4,000 contracts, $.9\times 4,000$ or 3,600 of the customer short positions are expected to be assigned with 400 being left open. Since arbitragers are short 16,000 contracts, $.9\times 16,000$ or 14,400 of the arbitrager short positions are expected to be assigned with 1,600 being left open. Multiplying by the windfall gain per contract and 100 shares per contract, the customers' gain is now \$16,000 and the arbitragers' gain is \$64,000. The total gain remains the same, \$80,000.

Note that the greater the activity of arbitragers, the smaller is the customers' expected gain. In general, the probability of a short being assigned may be written as

$$p=\frac{E_C+E_A}{OP_C+OP_A}, \tag{7}$$

where OP_C and OP_A are the open positions before exercises on day $t-1$ of customers and arbitragers respectively, and E_C and E_A are the number of exercises. The probability of not being assigned and hence profiting is $1-p$. The arbitrage opportunity arises because some customers who are long the call fail to exercise, that is, $E_C<OP_C$. Arbitragers, on the other hand, exercise all of their long call positions, $E_A=OP_A$. The greater the arbitrage activity (i.e., the higher is OP_A in relation to OP_C), the smaller the probability of not being assigned; the lower the probability, the smaller the expected gain per contract. But, since the arbitragers' number of contracts is increasing relative to the customers', the arbitrager is not assigned an increasing number of the unassigned contracts and hence captures more and more of the money left on the table. Under Scenario D in Table 1, we assume that the

[7]Technically speaking, a dividend spread trade is a trade done to achieve dividend arbitrage between <u>any</u> two deep in-the-money options.

[8]Typically the trades are done with another arbitrager at a price within the prevailing bid/ask quotes.

arbitrager simultaneously buys and sells 196,000 in-the-money calls. In this instance, the likelihood of a short's being assigned is

$$p = \frac{2,000 + 196,000}{4,000 + 196,000} = .99.$$

Since the arbitrager has the lion's share of the short contracts, he is expected to earn

$$196,000 \times (1 - .99) \times \$.40 \times 100 = \$78,400,$$

while the customers are now expected to earn only

$$4,000 \times (1 - .99) \times \$.40 \times 100 = \$1,600.$$

Again, the total value of the money on the table remains the same, at \$80,000.

A trader who intends to arbitrage the failure of some call holders to exercise has to consider several factors in choosing how to implement his strategy. First, he must assess which calls have the greatest profit potential relative to the costs of undertaking the strategy. The dollar gain from failure to exercise is

$$(S - X) - C(S^x, X, T) \tag{8}$$

and depends on the level of the dividend and the extent to which the option is in the money. Second, there must be sufficient open interest. If open interest is small, the unexercised calls will be few and the strategy relatively unprofitable. Third, the arbitrager must assess the probability that the natural call holders will not exercise their calls. No gain is possible if all of the open interest is exercised. If the failure to exercise on the part of the retail customers exists because they do not understand the benefit of early exercise when a stock pays a dividend, the failure to exercise would be unrelated to the gain (8). On the other hand, failure to exercise may reflect a balancing of benefits and costs, in which case certain options can be predicted to have a greater probability of exercise than others. If customers do exercise when the benefit is large, the arbitrager would not find it profitable to establish positions in those options. Instead, the arbitrager would establish positions in medium profit options.

The risks of the arbitrage strategy are relatively small. So-called dividend spread trades are pre-arranged between arbitragers with a price between the prevailing bid/ask quotes. The worst that can occur in a dividend spread trade is that the arbitrager is assigned to make delivery on all of his short option positions, in which case he is out-of-pocket only transaction costs. For large trades, however, transaction fees on the OCC and option exchanges are relatively low. The OCC, for example, has a sliding scale of volume discounts which results in a flat fee of \$55 to clear trades of more than 2,000 contracts. Transaction fees for dividend spreads on the stock options exchanges have been the source of controversy. While electronic exchanges such as the International Securities Exchange (ISE) and the Boston Options Exchange (BOX) have fees quoted on a per contract basis, the American Stock Exchange (AMEX), the Chicago Board Options Exchange (CBOE), the Pacific Exchange (PCX), and the Philadelphia Stock Exchange (PHLX) cap the total fee on dividend spreads.[9] On the AMEX, for example, a market maker faces transaction,

[9]The controversy is described in a recent Dow-Jones News release, "Amex, CBOE Lower Fees To Compete For Div-Spread Volume" (February 8, 2006) by Mohammed Hadi.

comparison, and brokerage fees amounting to \$.20 per contract side. The aggregate fee, however, is limited to \$1,000 per day.[10] This means that dividend spreads larger than 2,500 contracts on each side on the AMEX receive preferential treatment, at least relative to the ISE and BOX. For a dividend spread involving 50,000 contracts on each side, unit fees are reduced from \$.20 to \$.02. Since dividend spread trades are enormous relative to typical trade sizes, the exchanges offering preferential rates draw greater overall market share when measured by number of contracts traded vis-à-vis trade revenue.

In the event that not all contracts are assigned, the arbitrager is left with an open long stock/short call position. Note that the arbitrager can net the assignments against the exercises. In Scenario D of Table 1, for example, assignments of 194,040 can be netted against exercises of 196,000. As a result the arbitrager takes delivery of $1,960 \times 100$ shares of stock and retains a short call position of 1,960 contracts. There is some risk with respect to this residual position. First, there is the overnight market risk from having a position that may not be perfectly hedged. If the delta of the call is less than one, the trader has net long position in the stock equal to the difference between one and the option's delta. In other words, the trader is vulnerable to overnight market declines. Second, there may be market impact costs of unwinding the residual position. Selling a large stock position at the open on ex-dividend day may cause prices to fall. Similarly, covering a large short call position may cause call prices to rise. Finally, as with other arbitrage-style trading, there is the risk of "legging-out" when the stock and call are not liquidated simultaneously.

3. Data

The empirical analyses of this study are based on all exchange-traded call options on dividend-paying stocks traded in the US during the period January 1996–April 2006. The option data are drawn from Optionmetrics. Among other fields, the file includes closing bid/ask price quotes, trading volume, and closing open interest for each option series each day. Of particular importance is open interest information.[11] Recall that open interest on the day before ex-dividend measures failure to exercise. For the sub-period July 2001 through April 2006,[12] the Option Clearing Corporation (OCC) provided data on the number of contract exercises for each option series each day. The exercise data are classified into customer (C), market-maker (M), and firm (F), which makes it possible to determine the likely source of the dividend spread trades. The daily volume and open interest data combined with the exercise data allow us to gauge the number of new positions opened during the trading day. The closing stock price and dividend data were drawn from the CRSP daily files. Closing bid/ask price quotes for stocks were drawn from the NYSE's TAQ files. The proxy for the risk-free interest rate is based on the zero-coupon yield curve of rates for overnight, 7-day, 30-day, 90-day, 180-day, and one-year Eurodollar time deposits downloaded from Datastream.

[10]The CBOE and PCX also limit the aggregate fee on dividend spreads to \$1,000. The PHLX caps the aggregate fee at \$1,000 for trades involving dividends below \$.25 per share and at \$1,750 for trades involving dividends above \$.25/share.

[11]Users of OptionMetrics should note that on and after November 28, 2000, the open interest reported for a particular option series at the end of day t is actually the open interest for the series at the end of day $t-1$. Before November 28, 2000, the open interest reported for day t is correct.

[12]The OCC was unable to recover the historical exercise data for the months of November 2001, January and July 2002, and January 2006.

Table 2
Attributes of stocks and quarterly cash dividend payments of at least $.01 for sample of exchange-traded call options during the period January 1996–April 2006

No. of call option series on ex-dividend days	458,416
No. with exercise price below critical level	73,343
No. of option classes	1,959
No. of unique dividend payments	42,602
Average cash dividend payment	0.184
Average closing share price before ex-dividend day	54.128
Average closing share price on ex-dividend day	53.908

In addition to the information described above, an estimate of the expected future volatility rate is required in order to compute the critical exercise price. Using the implied volatility for each option series would seem to be a possibility; however, due to the "implied volatility smile,"[13] there remains the possibility that it is optimal to exercise one call early and suboptimal to exercise a deeper in-the-money call. To circumvent this problem, we use the annualized standard deviation of logarithmic returns over the most recent 60 trading days up to the valuation date.

Finally, in Section 2, we illustrated the computation of the critical exercise price under the assumption that there are no dividends remaining during the option's life after the ex-dividend day. Consequently, we were able to use the European-style Black-Scholes formula to compute the ex-dividend American-style call option value. In reality, however, multiple dividends are possible during the option's remaining life. Consequently, we use a cash dividend-adjusted binomial method to value the ex-dividend option values.[14] Naturally, the expected dividend stream is adjusted for any stock splits and stock dividends paid during the option's life. Stock split and stock dividend information were drawn from the CRSP files.

Relatively few exclusionary criteria were applied to the data. First, for an option class to be included in the sample, it must have traded at some time during the sample period and had concurrent data available on the Optionmetrics, CRSP, and TAQ data files. Second, only classes in which the stock's cash dividend was at least $.01 per share were considered. Third, excluded from the sample are special dividends exceeding 10% of the stock price, for the OCC adjusts the exercise price in these cases. Consequently, the incentive to exercise prior to the ex-day does not exist.

To get a sense of the attributes of the sample created using the data sources and exclusionary criteria, selected summary statistics were computed and are reported in Table 2. The total number of call option series appearing on ex-dividend days was 458,416. For each call option expiration in each option class, the critical exercise price was computed on the day before ex-dividend. All option series with exercise prices above their respective critical levels were eliminated since it is not in the call option holder's best interest to exercise. According to our implementation of the critical exercise price criterion, therefore, the number of occasions in our sample on which the call option holder should

[13]The implied volatility smile refers to the relation between implied volatility and exercise price for options with a common expiration date and underlying asset. For stock options, the relation generally appears as a smile. See, for example, Bollen and Whaley (2004).

[14]See Harvey and Whaley (1992).

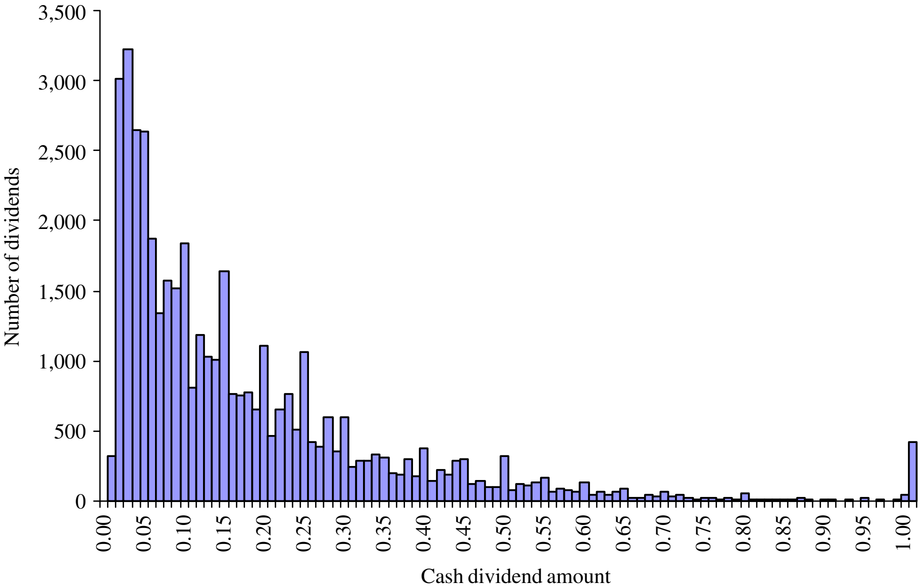

Fig. 1. Frequency distribution of cash dividend amounts for 1,959 stock option classes included during the sample period January 1996–April 2006. Number of unique ex-dividend payments is 42,602.

have exercised on the day before the ex-dividend day is 73,343. The number of stocks whose options were included in the sample is 1,959. The number of unique quarterly cash dividend payments (i.e., the number of times call option series should have been exercised) is 42,602. The average cash dividend amount is about $.184 per share. The average closing share price is $54.128 on the day before ex-dividend and $53.908 on the ex-dividend day. In other words, the average annualized dividend yield for the stocks in the sample is about 1.4%. Fig. 1 contains a frequency distribution of the cash dividend amounts. The distribution is skewed to the right, reflecting, among other things, large dividends paid on some stocks.

4. Failure to exercise and foregone profit

In this section, we examine whether transaction costs of exercising (or selling) call options are sufficient to explain the failure of some investors to exercise options on the day before the ex-day. To the extent that transaction costs are less than the profit foregone, we conclude that irrational or at least inattentive behavior of investors is the source of their failure to exercise. We proceed in five steps. In the first, we provide summary data of the underlying trading costs—commissions and bid-ask spreads—for the options and stocks in our sample. In the second, we examine the range of trading costs for alternative strategies to exit a call option position. In the third, we describe our measures of frequency of failure to exercise and foregone economic profit. In the fourth, we use Altria's nearby call options on March 10, 2005 (i.e., a day before ex-dividend) to illustrate the computation of our measures, and, finally, in the fifth, we describe and discuss the results across all option series during our sample period, January 1996–April 2006.

Table 3
Indicative or five option contracts (i.e., number of options on 500 shares) in dollars

Broker	Fixed fee	Variable fee (per share)	Per share for 500 shares
Trade stocks			
Merrill Lynch	29.95	None	\$0.06
Ameritrade	9.99	None	\$0.02
Trade options			
Banc America	19.95	0.015	\$0.06
Ameritrade	9.99	0.0075	\$0.03
Exercise options			
Banc America	42.50	None	\$0.09
Option Express	14.95	None	\$0.03

The data were collected from the fee schedules displayed on the brokers' internet sites.

4.1. Trading costs in the option and stock markets

Undoubtedly, trading costs play a key role in the early exercise decision as well as in determining who plays the dividend spread trading game. In a no trading cost environment, exercise on the day before ex-dividend is optimal if the call's exercise price is below the critical exercise price (i.e., $X < X^*$). In such a situation, the option holder is indifferent between exercising his call or selling the call in the marketplace. Both alternatives provide the dollar amount, $S - X$. In the actual marketplace, however, trading costs can be substantial and can affect the decision to exercise as well as the manner in which exercise is enacted. If the option holder instructs his broker to exercise the call, for example, the total trading costs are the sum of three components: a commission for exercising the call, and a commission and bid-ask spread for selling the stock delivered on exercise. If instead the investor simply sells the call, a commission and bid-ask spread are incurred.

Whether the investor exits his long call position and how he does so will depend on transaction costs in the option and stock market. Data on these costs are provided in Table 3 through 5. Commission rates are provided in Table 3 for different types of trades in the stock and option market. Rates vary depending on the type of broker, the level of service, and size of trade. Those reported are representative rates drawn from the internet sites of the selected full-service and discount brokers for on-line trading of 500 shares of stock or call options on 500 shares (i.e., five contracts). Absent other considerations, active customers would presumably migrate to the low-cost providers, but other considerations wind up being important. The trading software as well as the real-time data feeds of the high-cost brokers can be substantially better than the discount service providers. In moving forward through the analyses, therefore, we consider both types of retail customers. Finally, Table 3 shows a difference between the commissions for trading an option versus exercising an option. The activities are quite different. For the on-line brokerage services, selling the call on the day before ex-dividend day can be executed on-line. Exercising the call, however, requires the active assistance of a broker. The call option holder must contact his broker, electronically or otherwise, to instruct the broker to exercise. The broker, in turn, handles the mechanics of communicating the exercise decision to the clearinghouse.

Tables 4 and 5 contain summaries of the bid/ask spreads for calls in the 1,959 option classes on the day before an ex-dividend day in our sample, as well as the contemporaneous bid/ask spreads of the underlying stocks. The distinction between the tables is that Table 4 includes all call option series while Table 5 includes only the series whose exercise price is below its critical level. The spreads are tabulated across all option series and by option price range in Panel A and by year in Panel B. The results in Table 4 are broadly consistent with past findings in the sense that bid/ask spreads dropped after the year 2000. Two events triggered the reduction. First, in August 1999, option exchanges began to compete with one another by listing options already trading on another exchange. Second, in May 2000, the International Securities Exchange (ISE) introduced the first fully electronic options exchange, listing only the most actively traded options from other US options exchanges. Together, these events took competition among options exchanges to unprecedented levels. Where the average bid/ask spread across options was \$.3578 in 1999 as shown in Table 4, it fell to \$.2463 in 2002, a reduction of over 31%. De Fontnouvelle, Fishe, and Harris (2003) analyze spreads in 28 option classes that changed from single listing to multiple listing in 1999 and find a reduction on the order of 30% to 40% one year later.[15] Battalio, Hatch, and Jennings (2004) analyze effective spreads in 30 actively traded option classes between June 2000 and January 2002 and find a reduction of 60%.

Even with the reduction, however, average dollar bid/ask spreads in the call option market remain dramatically higher than in the underlying stock market–\$.3138 versus \$.1150 across all years of the sample. While, on first appearance, this suggests that option spreads are about three times larger than stock spreads, the relative difference is higher than that. The reason is that the averages reported in Table 4 are computed across option series. For the series in a particular class on a particular day, the stock's bid/ask spread is the same and is repeated in the computation of the average. A more accurate measure of relative trading costs is to average the ratio of the option spread to the stock spread across option series, and these values are reported in the last column of the table. A typical option spread is more than seven times as large as the underlying stock spread. At the same time, the average option price midpoint, \$6.33, is only a small fraction of the stock price midpoint, \$50.70. Indeed, the average ratio of option price to stock price is only .1243, as is shown in the second to last column of the table. In other words, if one were to consider the size of the spread relative to dollars invested, spread costs in the option market appear to be more than 25 times higher than in the stock market.

Another interesting feature of Table 4 is that stock bid/ask spreads have decreased dramatically relative to option bid/ask spreads over the sample period. From 1996 to 1998, for example, the average ratio of option spread to stock spread increased from 2.04 to 3.55, as is shown in Panel B of Table 4. This coincides with the NYSE's reduction of minimum tick size from eighths to sixteenths on June 24, 1997. An exchange's tick size provides a lower bound on the bid/ask spread. With no commensurate reduction of the tick size on the options exchange, which remained at one-eighth, it is not surprising to see an increase in the relative spread. The same phenomenon occurred in 2001, when the option/stock spread ratio increased from a level of 3.28–10.05. Apparently the move by stock and options exchanges to decimal pricing, which was completed in April 2001, had much more impact on spreads in the stock market than options market. While the minimum price

[15] We replicated the De Fontnouvelle, Fishe, and Harris (2003) analysis using Optionmetrics data for options on 21 of their stocks, and we found a similar decrease in bid-ask spreads.

Table 4

Bid/ask spreads for call options and underlying stock on the day before ex-dividend for sample of exchange-traded option classes during the period January 1996–April 2006

Panel A: All option series by option price

Option price range		No. of obs.	Option		Underlying stock			No. of days to expiration	Average ratio of option price to stock price	Average ratio of option spread to stock spread
Lower	Upper		Average price	Average bid/ask spread	Average price	Average bid/ask spread	Dividend			
0		458,416	6.3281	0.3138	50.7026	0.1150	0.2159	99.1	0.1243	6.9922
0	3	215,823	1.1840	0.2013	41.0737	0.1081	0.2007	94.4	0.0400	4.8282
3	6	91,706	4.3222	0.3248	47.4896	0.1155	0.2111	105.5	0.1210	7.6779
6	10	63,817	7.7408	0.3839	54.8030	0.1180	0.2234	103.2	0.1775	8.7585
10	15	39,291	12.1567	0.4822	63.1705	0.1202	0.2347	99.9	0.2335	10.4488
15	20	19,727	17.2074	0.4962	71.6156	0.1242	0.2471	98.8	0.2848	10.1908
20	25	10,621	22.2351	0.5683	78.9305	0.1280	0.2596	100.1	0.3284	10.7399
25	∞	17,431	40.2584	0.6514	102.8437	0.1571	0.2961	106.5	0.4380	10.0178

Panel B: All option series by year

Year	No. of obs.	Option		Underlying stock			No. of days to expiration	Average ratio of option price to stock price	Average ratio of option spread to stock spread
		Average price	Average bid/ask spread	Average price	Average bid/ask spread	Dividend			
1996	27,501	5.2524	0.3494	47.9009	0.2023		101.6	0.1086	2.0371
1997	37,061	6.3957	0.3874	51.6576	0.1679	0.2394	94.2	0.1206	3.1698
1998	41,987	6.0931	0.3763	49.6470	0.1469	0.2154	96.4	0.1165	3.5461
1999	41,463	6.6380	0.3578	47.0572	0.1326	0.1921	96.3	0.1299	3.6208
2000	42,746	7.6275	0.3344	49.3759	0.1566	0.1916	96.2	0.1376	3.2772
2001	40,312	5.0486	0.2740	45.8757	0.0928	0.1847	99.3	0.1157	10.0477
2002	41,789	4.5900	0.2463	43.9339	0.0895	0.1846	101.0	0.1121	9.1962
2003	38,171	5.9946	0.2591	46.9129	0.0889	0.1998	99.7	0.1372	8.9406
2004	56,741	6.1460	0.2691	53.3926	0.0789	0.2246	102.4	0.1226	9.6996
2005	69,484	7.5128	0.3187	57.8694	0.0801	0.2354	102.2	0.1320	10.0520
2006	21,161	7.9116	0.2979	63.2401	0.0781	0.2780	97.2	0.1250	10.0805

The number of option classes (i.e., underlying stocks with quarterly dividends exceeding \$.01) is 1,959, and the number of unique dividend payments is 42,602. The number of call option series is 458,416.

Table 5
Bid/ask spreads for call options and underlying stock on the day before ex-dividend for sample of exchange-traded option classes during the period January 1996–April 2006

Panel A: All option series by option price

Option price range		No. of obs.	Option		Underlying stock			No. of days to expiration	Average ratio of option price to stock price	Average ratio of option spread to stock spread
Lower	Upper		Average price	Average bid/ask spread	Average price	Average bid/ask spread	Dividend			
0	∞	73,343	11.0451	0.3811	49.7456	0.0880	0.3183	48.8	0.2305	11.1250
0	3	9,833	1.9085	0.2436	33.0484	0.0829	0.2871	29.0	0.0827	7.3883
3	6	17,184	4.4630	0.3275	37.2029	0.0811	0.2855	42.8	0.1559	10.6878
6	10	17,197	7.8340	0.3648	44.8005	0.0824	0.2992	48.5	0.2155	11.3283
10	15	12,656	12.2067	0.4312	53.7627	0.0878	0.3177	53.4	0.2728	12.8351
15	20	6,815	17.2353	0.4401	63.5130	0.0958	0.3461	58.2	0.3201	12.2213
20	25	3,834	22.2493	0.4889	71.2612	0.1045	0.3694	63.7	0.3599	12.4948
25	∞	5,824	38.2304	0.5703	90.5422	0.1138	0.4593	70.0	0.4626	12.2231

Panel B: All option series by year

Year	No. of obs.	Option		Underlying stock			No. of days to expiration	Average ratio of option price to stock price	Average ratio of option spread to stock spread
		Average price	Average bid/ask spread	Average price	Average bid/ask spread	Dividend			
1996	2,744	9.4665	0.4439	51.3432	0.1939	0.3989	38.3	0.1825	2.6584
1997	4,329	10.1998	0.4840	51.6373	0.1684	0.3459	28.9	0.1972	3.9242
1998	3,468	10.5750	0.4957	51.8130	0.1444	0.3423	28.0	0.2025	4.6944
1999	3,790	10.8403	0.4629	46.5826	0.1277	0.2886	28.9	0.2252	4.7825
2000	3,114	10.7991	0.4385	44.5343	0.1382	0.2910	24.8	0.2301	4.5067
2001	4,579	9.5805	0.3764	43.4322	0.0683	0.3010	38.5	0.2300	15.2894
2002	6,289	10.0472	0.3434	43.0528	0.0589	0.2692	49.4	0.2465	14.6659
2003	12,168	10.8429	0.3229	47.0928	0.0782	0.2597	64.8	0.2489	11.7501
2004	15,365	11.2257	0.3492	51.9406	0.0679	0.3080	64.8	0.2326	13.3267
2005	13,633	12.3085	0.3845	53.2406	0.0646	0.3547	47.4	0.2363	13.3004
2006	3,864	12.7560	0.3562	57.6067	0.0565	0.4567	38.6	0.2201	13.4350

The number of option classes (i.e., underlying stocks with quarterly dividends exceeding $.01) is 1,959, and the number of unique dividend payments is 42,602. The number of call option series with exercise prices below critical levels is 73,343.

increment in stocks went to one penny, the minimum in options went to \$0.05 (from \$0.0625) for options quoted at less than \$3.00 and to \$0.10 (from \$0.125) for options quoted at more than \$3.00.[16] Whereas stock spreads were nearly halved, options spreads remained at nearly the same levels as in previous years.[17]

Table 5 contains the same summary statistics as Table 4; however, the sample includes only call options that should be exercised (i.e., calls whose exercise price is below its critical level on the day before ex-dividend). While the inferences concerning movements in the stock and option spreads are the same as those in Table 4, the absolute levels of option spreads are higher. In Table 4, for example, the average bid/ask spread for call options is \$.3138, while the average bid/ask spread for call options that should be exercised is \$.3811, about seven cents higher. This result is expected in the sense that bid/ask spreads generally get larger as the call option moves further and further in the money. Naturally, calls whose exercise prices are below critical levels are deep in the money.

4.2. The exercise decision and trading costs

The cost of exiting the long call position depends on how the exit is accomplished and what new position is established. There is a range of possibilities. Our approach is to specify reasonable investor objectives and establish a reasonable range of transaction costs.

4.2.1. Exit long call position

One objective is simply to exit the long call position by exercising the call or by selling the call. Exercising the call necessitates a commission to the broker for exercising the call, $Comm_{XO}$. Then, in order to liquidate the newly-acquired stock position, a stock commission, $Comm_S$, and one-half the stock's prevailing bid/ask spread, $Sprd_S$, are required. Thus, the total costs are

Customer exercises call:

$$TC_1 \equiv Comm_{XO} + Comm_S + \tfrac{1}{2}Sprd_S. \tag{9}$$

They are not option-specific. On the other hand, if the option holder sells the call, the costs are a trading commission on the option, $Comm_{TO}$, plus one-half of the bid/ask spread of the option, $Sprd_O$, that is,

Customer sells call:

$$TC_2 \equiv Comm_{TO} + \tfrac{1}{2}Sprd_O. \tag{10}$$

Since the bid/ask spread of the options varies by series, the decision to sell is option-specific. Thus, for an existing call option holder, the decision about whether to exercise the call depends on whether the difference between the exercise proceeds on the day before ex-dividend and the ex-dividend option value exceeds (9) or (10), and the decision about enacting exercise by directly exercising it or selling it in the marketplace depends on which of the quantities (9) or (10) is less.

[16] As reported in U.S. SEC, Concept Release: Competitive Developments in the Options Markets. Release No. 34-49175, Feb. 3, 2004, p. 16. In 2007, a pilot program to trade selected options in penny increments was authorized by the SEC.

[17] Keep in mind, of course, that our sample contains option spreads only on the day before ex-dividend day. To the extent that spreads are different on other trading days, our results may not be representative of a more general phenomenon.

Using the data in Table 3 and Table 5, we can estimate the costs (9) and (10). Commissions per share for exercising the option and selling the stock (from Table 3) are \$.03 and \$.02 respectively. A reasonable approximation of the bid/ask spread in stocks (from Table 5) is $Sprd_S = \$.0880$. Thus if the investor exercises the call and sells the stock as in (9), the total transaction cost is $\$.03 + .02 + \frac{1}{2}(.0880) = \$.0940$ per share on average. On the other hand with option spreads at $Sprd_O = \$.3811$ and option commission at \$.03, if the customer sells the call in the market as in (10), the total cost is $\$.03 + \frac{1}{2}(.3811) = \$.2206/\text{share}$. The difference is quite large. The observed spreads in the option market make selling the call, as an implicit exercise alternative, unpalatable. In moving forward through the remaining analyses, therefore, we assume that exercising the call is the preferred method of exiting the call position, if exercise is warranted. Thus an investor who is ready to exit the long call position will do so on the day prior to the ex-dividend day if the following condition is met:

$$(S - X) - C(S^x, X, T) > TC_1. \tag{11}$$

4.2.2. Roll into new long call position

Some investors may not wish to exit their long call position but instead may wish to rollover into the same position. This is because they have a particular investment strategy they wish to maintain. These individuals will want to exercise their call position on the day before ex-dividend, if it is optimal to do so, and will want to replace the call option position on the following morning so as to maintain their pre-exercise level of expected utility. The total trading costs incurred by such an action are

$$\text{Customer rolls call}: TC_3 \equiv Comm_{XO} + Comm_S + \frac{1}{2}Sprd_S + Comm_{TO} + \frac{1}{2}Sprd_O. \tag{12}$$

In calculating the cost (12), we shall also assume that investors use the high-cost broker in order to generate an upper bound on trading costs. Some customers are willing to pay higher commissions to receive a more responsive on-line trading platform, real-time market data, and firm research. Using the highest commission rates from Table 3 and the bid/ask spreads from Table 5 generates a rollover cost of

$$\$.09 + .06 + \tfrac{1}{2}(.0880) + .06 + \tfrac{1}{2}(.3811) = \$.4446.$$

4.2.3. Other investor objectives and other transaction costs

We believe that TC_1 and TC_3 are reasonable bounds on the trading costs faced by ordinary option investors. Needless to say there are other investor objectives that might impose higher or lower costs. If the investor's objective were to take possession of the stock, for example, the cost might be lower than TC_1 (since the stock would not have to be sold). Alternatively if the investor were covering a short position in exercising the call option, there might be additional costs of returning the stock to the lender. We believe any such costs would be less than our high cost alternative, TC_3.

Taxes should not affect the exercise decision for an investor. The failure to exercise when the gain from early exercise exceeds the transaction costs is a foregone profit. Taxes may reduce the after-tax value of that foregone profit but will not eliminate it.

It is important to note that there is one sense in which our trading cost estimates TC_1 and TC_3 are too high. Many of the call options in our sample are of short remaining maturity and all are deep in the money. Hence, the investor will soon be required to exercise or sell the option under any circumstances. The additional cost of exercising before the ex-dividend day is small. By overestimating transaction costs, we underestimate the extent to which the failure to exercise is irrational.

4.2.4. Summary

In summary, we will move forward with the following characterization of the call option holder's exercise decision. In the case where the exercise proceeds exceed the ex-dividend call option value by more than the high-cost customer's rollover cost,

$$(S - X) - C(S^x, X, T) > TC_3, \tag{13}$$

we will label failures to exercise as being attributable to trader irrationality or monitoring costs. Labeling failures to exercise where

$$TC_3 \geqslant (S - X) - C(S^x, X, T) > TC_1 \tag{14}$$

is difficult since it is entirely possible that customer trading costs are the culprit. For a low-cost customer with no aspiration of replacing his call position, however, the decision not to exercise is irrational. Finally, failures to exercise when the deviation is positive but less than trading costs (9),

$$TC_1 \geqslant (S - X) - C(S^x, X, T) > 0, \tag{15}$$

are rational. Even low-cost customers will find the exercise decision to be unprofitable. Consequently, in measuring the economic value forfeited by failure to exercise, we separate the quantities (13)–(15).

4.3. Measures of failure to exercise and foregone economic profits

In our first investigation, we examine the frequency with which call option holders fail to exercise when they should and the amount of money that is left on the table as a result of suboptimal exercise. To measure the former, we compute the ratio

$$\frac{OI_{t-1}}{OI_{t-2}} \tag{16}$$

for each eligible option series each day.[18] Where the ratio is 0, all customer long positions existing on day $t-2$ are being exercised as they should. Where the ratio is 1, no one exercises. Under Scenarios A and B of Table 1, the ratios are 0 and .5, respectively.

The total economic profit forfeited when some option holders fail to exercise is directly proportional to the open interest remaining at the close on the day before ex-dividend. To measure the money left on the table, we compute the quantity

$$OI_{t-1} \times [S_{t-1} - X - C(S_{t-1} - D, X, T)] \times 100. \tag{17}$$

For all call options with exercise prices below the critical price, X^*, the immediate exercise proceeds at the close on the day prior to ex-dividend, $S_{t-1} - X$, are greater than the value of the call after the ex-dividend instant, $C(S_{t-1} - D, X, T)$. The total value forfeited on unexercised positions, therefore, is the number of contracts left open times the

[18] Note that arbitrager activity does not show up in end-of-day open interest level since the contracts that are entered into on day $t-1$are exercised the same day.

difference between the exercise proceeds and the ex-dividend option value times 100. The ex-dividend option value is computed under the Black-Scholes (1973)/Merton (1973) assumptions using the cash dividend-adjusted binomial method.

As noted earlier, however, not all of this money (17) could have been earned by call option holders. The deviation between the exercise proceeds and the ex-dividend option value must exceed trading costs. Consequently, the total money left on the table is separated into three quantities. The dollar amount,

$$OI_{t-1} \times \max\left[0, S_{t-1} - X - C(S_{t-1} - D, X, T) - TC_{3,t-1}\right] \times 100, \tag{18}$$

is forfeited by call option holders as a result of irrationality or failure to monitor, where $TC_{3,t-1}$ is defined by (12) and uses the prevailing spread in the stock market on the day before ex-dividend.[19] The dollar amount,

$$OI_{t-1} \times \max\left[0, \min\left[TC_{3,t-1} - TC_{1,t-1}, S_{t-1} - X - C(S_{t-1} - D, X, T) - TC_{1,t-1}\right]\right] \times 100, \tag{19}$$

is forfeited by low-cost customers. In this region, trader irrationally/monitoring costs cannot be ruled out since we have no means of identifying the nature of the customers who hold outstanding long call positions. Finally, the dollar amount,

$$OI_{t-1} \times \min\left[TC_{1,t-1}, S_{t-1} - X - C(S_{t-1} - D, X, T)\right] \times 100, \tag{20}$$

is left on the table; however, it is not accessible to either high-cost or low-cost customers. Naturally, in the absence of trading costs, the full amount (17) could be earned by the customer.

4.4. An illustration of measurements

Before examining summary statistics across all stock option classes, an illustration may help to clarify the different concepts and measurements that we have introduced. The illustration is based on nearby Altria call options at the close of trading on March 10, 2005, the day before Altria's stock goes ex-dividend. The closing price and open interest data are reported in Table 6. Altria's stock price closed at \$65.49/share. The closing bid/ask quotes of the stock were \$65.44/\$65.49. The amount of the promised dividend was \$.73/share. The nearby contract had exercise prices ranging from \$30 to \$75 and had 9 days remaining to expiration. The 9-day risk-free rate of interest[20] was 2.63%, and the historical volatility rate of Altria's stock over the previous 60 trading days was 18.1%.

The first concept that we introduced (in Section 2) was the critical exercise price. We can solve for the critical exercise price below which all nearby call option series should be exercised prior to ex-dividend, X^*. We use (3) to solve

$$65.49 - X^* = C\left(65.49 - .73, X^*, 9/365\right). \tag{21}$$

The value of X^* is \$64.71, which means that, ignoring trading costs, all 9-day call options on Altria's stock with exercise prices below \$64.71 should be exercised immediately

[19] The stock spread when the stock position is liquidated is assumed to be the same as at the close of trading when the exercise decision was made.

[20] The proxy for the risk-free interest rate is the continuously compounded rate on a Eurodollar time deposit with a time to maturity equal to the life of the option.

Table 6
Open interest behavior for Altria call option series with 9 days to expiration and exercise prices below the critical price, \$64.71, in days leading up to the ex-dividend date, March 11, 2005

Exercise price	Open interest			Percent unexercised (%)	Closing price		Cum-dividend exercise value	Ex-dividend option value	Value forfeit	Money left on table			
	$t-2$	$t-1$	t		Bid	Ask				Exceeds rollover costs	Exceeds exercise costs	Exceeds zero	Total
30	10	0	0	0.0	35.40	35.60	35.49	34.779	0.711	0	0	0	
32.5	30	0	0	0.0	32.90	33.10	32.99	32.281	0.709	0	0	0	0
35	144	0	0	0.0	30.40	30.60	30.49	29.783	0.707	0	0	0	0
37.5	4	0	0	0.0	27.90	28.10	27.99	27.284	0.706	0	0	0	0
40	214	4	4	1.9	25.40	25.60	25.49	24.786	0.704	147	104	29	280
42.5	75	0	0	0.0	22.90	23.10	22.99	22.288	0.702	0	0	0	0
45	96	20	20	20.8	20.40	20.60	20.49	19.789	0.701	731	520	149	1,400
47.5	7,838	7,520	7,520	95.9	17.90	18.10	17.99	17.291	0.699	273,727	195,520	56,399	525,646
50	7,019	91	111	1.3	15.40	15.60	15.49	14.792	0.698	3,303	2,366	682	6,351
55	14,683	227	317	1.5	10.40	10.60	10.49	9.796	0.694	8,149	5,902	1,702	15,753
60	24,591	667	738	2.7	5.40	5.60	5.49	4.801	0.689	23,611	17,342	5,002	45,955
65	76,430	71,398	68,804	93.4	0.45	0.55	0.49	0.642	−0.152				
70	22,947	22,688	22,717	98.9	0.00	0.05	−4.51	0.002	−4.512				
75	4,830	4,830	4,830	100.0	0.00	0.05	−9.51	0.000	−9.510				
									Total	309,668	221,754	63,963	595,385

The stock price at close on the day before ex-dividend, S_{t-1} was \$65.49. The prevailing bid/ask price quotes at the close were \$65.44/\$65.49. The amount of the promised dividend on the ex-dividend day, D_t , was \$.73.

before the stock goes ex-dividend.[21] According to this model-dependent exercise criterion, therefore, all option series with exercise prices from \$30 through \$60 should be exercised immediately.

The contents of Table 6 are as follows. The first column identifies the option exercise price. The second through fourth columns are the end-of-day open interest in the days leading up to and including the ex-dividend day. The "Percent unexercised" column is computed using the ratio (16). Note that for certain options series such as the 30 through 37.5 exercise prices, the percent unexercised is 0% (or, alternatively, the open interest on the day before ex-dividend day is 0). This should be the case for all option series in the table with exercise prices below \$64.71, but it is not. About 21% of the calls with the \$45 exercise price, for example, remained unexercised, as did about 96% of the calls with the \$47.5 exercise price. The sixth through ninth columns contain the closing bid/ask call prices quotes at the close of trading.

The eighth column is the cum-dividend exercise value of the call on the day before ex-dividend. It is simply the closing stock price less the exercise price of the option. For the \$30 exercise price series, the value is \$35.49. To the immediate right is the ex-dividend call option value, $C(S_{t-1} - D, X, T)$, computed using the ex-dividend stock price, $\$65.49 - .73 = \$64.76$. The value of this deep in-the-money option is \$34.779, near its floor value, $\$64.76 - 30 = \$34.76$. The column headed "Value forfeit" is the difference between the immediate exercise proceeds and the ex-dividend call option value. This is the value forfeited by the option holder in the absence of trading costs if he fails to exercise. Note that the value forfeited is negative for the calls with exercise prices of \$65 and above. This stands to reason since the critical exercise price is \$64.71.

The final three columns contain the money left on the table. The computations underlying these figures are expressions (18)–(20). For the call options in the table, the trading costs of exercising are the sum of the commission rate of the option, the commission rate of the stock, and half of the bid/ask spread of the stock. The bid/ask spread of the stock is \$.05. Consequently, the assumed cost of exercising Altria call options on this day for a low-cost customer was

$$TC_{1,t-1} = \$.03 + .02 + \frac{1}{2}(.05) = .075.$$

The rollover cost for a high-cost customer depends on the spread of the particular option series. For the call with an exercise price of \$50, the option's bid/ask price quotes were \$15.40/15.60, hence the bid/ask spread was \$.20. The rollover cost was, therefore,

$$TC_{3,t-1} = \$.09 + .06 + \frac{1}{2}(.05) + .06 + \frac{1}{2}(.20) = \$.335.$$

With these trading cost estimates in hand, we now turn to partitioning the money left on the table. For the call with an exercise price of \$50, the value forfeited in the absence of trading costs is \$.698. For the high-cost trader, the rollover cost is \$.335, so this customer forfeits $\$.698 - .335 = \$.363$ by failing to exercise his call. In all, 91 calls were not exercised and each call represents 100 shares, so the money left on the table as a result of irrational

[21]On the same day, Altria also had call options with 37, 100 and 191 days to expiration. The critical exercise prices for these expirations were \$62.48, \$60.84, and \$59.11, respectively. As the call's time to expiration grows large, the time value of the call ex-dividend rises so the critical exercise price falls.

Table 7
Summary of frequency of irrational exercise and amount of money left on table by exchange-traded call option holders during the sample period January 1996–April 2006

Year	No. of observations	Open interest		Percent unexercised (%)	Money left on table				
		Day *t*–2	Day *t*–1		Exceeds rollover costs	Exceeds exercise costs	Exceeds zero	Total	Average monthly
1996	2,744	1,386,149	767,372	55.4	1,857,165	4,675,852	7,022,002	13,555,019	1,129,585
1997	4,329	1,803,516	912,995	50.6	5,586,340	6,822,144	7,826,963	20,235,447	1,686,287
1998	3,468	1,479,806	735,176	49.7	8,809,460	6,471,549	5,839,544	21,120,553	1,760,046
1999	3,790	1,303,296	769,218	59.0	2,400,471	6,004,873	5,890,249	14,295,593	1,191,299
2000	3,114	1,318,261	775,411	58.8	30,981,089	6,650,236	6,155,066	43,786,391	3,648,866
2001	4,579	2,066,393	1,463,598	70.8	7,107,439	10,512,469	7,504,583	25,124,491	2,093,708
2002	6,289	2,737,427	1,726,923	63.1	5,909,299	10,905,914	9,482,116	26,297,329	2,191,444
2003	12,168	9,517,506	5,802,808	61.0	9,323,351	39,863,777	30,938,497	80,125,625	6,677,135
2004	15,365	12,967,543	7,094,601	54.7	23,123,047	45,087,117	37,781,692	105,991,856	8,832,655
2005	13,633	14,046,679	6,355,315	45.2	26,803,448	45,893,661	31,410,184	104,107,293	8,675,608
2006	3,864	4,561,968	1,817,595	39.8	9,763,981	16,799,507	9,830,587	36,394,075	9,098,519
Total	73,343	53,188,544	28,221,012	53.1	131,665,090	199,687,099	159,681,483	491,033,672	

The number of option classes (i.e., unde dividend payments is 42,602. The numbe rlying stocks with quarterly dividends exceedin r of call option series with exercise prices below g $.01) is 1,9 critical levels 59, and the number of unique is 73,343.

traders or monitoring costs was $\$.363 \times 91 \times 100 = \$3,303$. In the range between the rollover cost of the high-cost customer and the exercise cost of the low-cost customer, the value forfeited is$(\$.335 - .075) \times 91 \times 100 = \$2,366$. Finally, the amount of money left on the table by customers by necessity is $\$.075 \times 91 \times 100 = \$682$. The total money left on the table absent trading costs is $6,351. For the $47.5 exercise price series, $273,727 was left on the table due to irrationality and/or monitoring costs, $195,520 by low-cost customers, and $56,399 was left due to the existence of minimal trading costs. The totals at the bottom of the columns show that the total money left on the table, $595,385, is made up of three components—$309,668 attributable to irrationality or monitoring costs, $221,754 by low-cost customers, and $63,963 to trading costs.

4.5. Aggregate results

We now turn to behavior in aggregate by examining all of the stock options in the sample year by year. The results are reported in Table 7. The results are stunning, to say the least. The second column presents the number of call option series on an ex-dividend day. Note that the sum across years is 73,343, exactly the same number as is reported in Table 2. The third and fourth columns represent the aggregate open interest across option classes at the end of the day two days and one day before ex-dividend, respectively, for options that should have been exercised. The "Percent unexercised" is the ratio of the latter to the former. In 1996, 55.4% of open call option contracts were not exercised when they should have been, causing a total of $13.6 million to be left on the table. The percent of open contracts has diminished through time, falling to a level of 39.8% in the first four months of 2006. Across all years, however, the failure to exercise exceeds 53% of outstanding contracts.

The money left on the table columns on the right hand-side of Table 7 provide compelling evidence that a significant number of failures to exercise are attributable to customers acting irrationally or failing to monitor their contract positions and the payout of the underlying stocks. In developing our estimate of rollover costs, we used commission rates typical of full service brokers. Thus, the money left on the table after rollover costs represents money that could have been earned by even high-cost customers. Over the 10+ year sample period, $132 million of economic value was forfeited by such customers. Another $200 million represents potential gains by low-cost customers, with $160 million being inaccessible due to minimal trading costs. Looking at the year-by-year results, we see that, even though a greater proportion of exercises are taking place, the amount of money being left on the table has grown, reaching an average monthly amount of $9.1 million in 2003.[22]

5. Volume effects of dividend spread arbitrage

Knowing that many call option holders will fail to exercise on the day before ex-dividend, dividend spread arbitragers step in, sell calls, and hope not to be assigned. As noted earlier, the larger the short position for a particular arbitrager, the greater the number of calls that will not be assigned. To hedge against adverse price movements in the underlying stock, the arbitrager also buys an equal number of calls, but, unlike the

[22]We report average monthly figures here since our sample includes only the first four months in 2006.

Table 8
Trading volume, open interest, and number of exercises for Altria call option series with 9 days to expiration and exercise prices below the critical price, \$65.18, in days leading up to the ex-dividend date, March 11, 2005

Exercise Price	Trading volume			Open interest			Number of exercises		
	$t-2$	$t-1$	t	$t-2$	$t-1$	t	Estimated	Actual	Deviation
30	0	52	0	10	0	0	62	62	0
32.5	0	304	0	30	0	0	334	182	−152
35	0	1,052	0	144	0	0	1,196	1,196	0
37.5	0	0	0	4	0	0	4	4	0
40	0	2,004	0	214	4	4	2,214	2,212	−2
42.5	0	452	0	75	0	0	527	527	0
45	0	852	0	96	20	20	928	928	0
47.5	0	134,508	0	7,838	7,520	7,520	134,826	134,820	−6
50	5	137,754	20	7,019	91	111	144,682	146,038	1,356
55	88	348,473	90	14,683	227	317	362,929	380,059	17,130
60	466	565,109	118	24,591	667	738	589,033	580,217	−8,816
65	3,939	8,464	1,897	76,430	71,398	68,804	13,496	3,852	−9,644
70	0	1,481	170	22,947	22,688	22,717			
75	0	0	0	4,830	4,830	4,830			
Total							1,250,231	1,250,097	−134

The stock price at close on the day before ex-dividend was \$65.49, and the amount of the promised dividend was \$.73.

customer, he exercises them fully.[23] The purpose of this section is to document the abnormal trading activity that dividend spread arbitrage creates.

5.1. Trading volume and estimated number of exercises

To clarify the relation between trading volume and number of exercises each day, we continue using the Altria call option series in the days surrounding the March 11, 2005 ex-dividend day as an illustration. Table 8 contains trading volume and open interest information for call option series with 9 days to expiration. Note the striking level of trading volume for the call option with the \$60 exercise price, an astounding 565,109 contracts (compared to 466 a day earlier)! At the same time, open interest declined from 24,591 two days before the ex-dividend day to 667. Given the size of the bid/ask spread in the option market relative to the stock market on the day before ex-dividend, customers have no incentive to either open or close positions.[24] Hence, it is reasonable to assume that the trading volume is being generated by arbitragers and that trading volume is all opening buys volume, that is, $TV_{t-1} = OB_{t-1}$. Setting $CS_{t-1} = 0$, our estimator for the actual number of exercises is

$$E(E_{t-1}) = -(OI_{t-1} - OI_{t-2}) + TV_{t-1}. \quad (22)$$

[23]The arbitrager takes delivery only of the net of exercises over assignments.

[24]Assuming the call option should be exercised on the day before ex-dividend, the bid/ask prices of the option will straddle the exercise proceeds, $S - X$. Because the ask price exceeds the exercise proceeds, a rational customer will not buy the option since he can simply buy the stock directly at a lower half spread. Conversely, a customer with an existing long position has no incentive to reverse his position at the bid price since he can simply exercise the call at a lower cost.

Substituting the information from Table 8, our estimate of the number of exercises is

$$E(E_{t-1}) = -(667 - 24,591) + 565,109$$
$$= 589,033$$

which is very close to the actual number of exercises for the day, 580,217. In other words, the newly established positions on day $t-1$ were liquidated by exercise within the day. This means that approximately 565,109/589,033 or 95.9% of the money left on the table by call option holders went to the arbitragers.

To demonstrate that our procedure for estimating the number of contracts is reliable, we regress the actual number of call contracts exercised for each option series on the day before ex-dividend, E_{t-1}, on the estimated exercises, $E(E_{t-1})$, for all call options series for which we had actual exercise data from the OCC. The total number of observations in the regression is 36,469. The results are reassuring. The regression produces an adjusted R-squared, level of 97.5%. The fitted regression relation is

$$\hat{E}_{t-1} = 11.70 + .9943(OI_{t-1} - OI_{t-2} + TV_{t-1}),$$

where the standard errors of the intercept and slope coefficients are 23.1276 and .0008397, respectively. This means that the null hypothesis that the intercept is zero cannot be rejected at the five percent probability level (i.e., t-ratio is .5061), but that the null hypothesis that the slope equals one can be rejected (i.e., t-ratio is 6.844). From a practical standpoint, however, the slope is virtually one, and our estimator of number of exercises appears reliable.

5.2. Growth in dividend spread trading

To illustrate the growing practice of dividend spread arbitrage, we compute total trading volumes for calls and puts as well as the underlying stocks for the 1,959 option classes during the sample period January 1996–April 2006. Two sets of computations are performed. The first set sums volume across all days in the year except the day before ex-dividend. The other set sums volume on the day before ex-dividend only. Table 9 contains the results. In Panel A, we see that call options are generally more active than put options—call volume is about 7.47% of stock volume while put volume is only 4.80%. It is also apparent that the relative volume of options to stocks is growing through time. Whereas put volume was only 3.43% of stock volume in 1996, it rose to 7.70% in 2006. For call options, the results in Panel B show a startling contrast. On average, call volume was 32.21% of stock volume on days before ex-dividend, more than four times higher than the 7.47% reported in Panel A. What is even more remarkable, however, is the rate of growth in call volume through time. Where call volume was 13.42% of stock volume in 1996, it was 121.67% in the first four months of 2006. In other words, on the day before ex-dividend, more shares trade hands indirectly in the call option market than directly in the stock market.

The degree to which normal trading can be disrupted can also be seen by examining the call option series with the highest trading volume on the day before ex-dividend. In our sample of 73,343 call option series which should have been exercised on the day before ex-dividend, 20 had trading volumes in excess of 500,000 contracts. These are listed in Table 10. Eight of the 20 series belonged to Altria. The March 2006 call with an exercise

Table 9
Total trading volume of calls, puts, and underlying stocks during the sample period January 1996–April 2006

Year	Number of option contracts traded		Number of shares traded	Relative volumes		
	Calls	Puts		Calls to stock (%)	Puts to stock (%)	Calls to puts
A. All days other than day before ex-dividend day						
1996	79,287,978	35,617,912	103,806,034,194	7.64	3.43	2.226
1997	108,373,854	51,596,137	138,434,351,914	7.83	3.73	2.100
1998	132,595,373	64,332,407	181,039,154,326	7.32	3.55	2.061
1999	168,447,299	78,205,864	227,045,161,332	7.42	3.44	2.154
2000	224,877,214	124,864,005	309,820,951,156	7.26	4.03	1.801
2001	246,951,879	168,035,378	361,109,406,772	6.84	4.65	1.470
2002	274,424,166	206,736,352	440,539,498,492	6.23	4.69	1.327
2003	236,333,122	175,288,341	424,431,925,214	5.57	4.13	1.348
2004	360,412,720	279,207,279	447,069,742,553	8.06	6.25	1.291
2005	441,251,710	369,724,468	515,672,096,025	8.56	7.17	1.193
2006	182,542,065	148,602,243	192,961,940,771	9.46	7.70	1.228
Mean				7.47	4.80	1.655
B. Day before ex-dividend day only						
1996	1,881,825	419,583	1,402,407,187	13.42	2.99	4.485
1997	2,301,208	646,597	1,893,103,605	12.16	3.42	3.559
1998	2,836,353	786,440	2,340,588,352	12.12	3.36	3.607
1999	2,226,844	766,165	2,758,468,182	8.07	2.78	2.906
2000	3,487,695	987,031	3,361,856,801	10.37	2.94	3.534
2001	3,885,644	1,575,151	3,707,495,424	10.48	4.25	2.467
2002	5,359,771	2,059,451	4,475,773,613	11.98	4.60	2.603
2003	16,315,366	2,201,696	4,775,813,796	34.16	4.61	7.410
2004	24,996,163	3,776,973	5,555,091,003	45.00	6.80	6.618
2005	58,636,224	6,908,124	7,829,091,390	74.90	8.82	8.488
2006	33,698,949	2,716,123	2,769,750,796	121.67	9.81	12.407
Mean				32.21	4.94	5.280

To compute option volume to stock volume (i.e., relative volume) option volume is first multiplied by 100 (i.e., number of shares per contract). The number of option classes (i.e., underlying stocks with quarterly dividends exceeding $.01) is 1,959.

price of 70 traded 1.8 million contracts on March 10, 2006, as did the January 2006 call with an exercise price of 65 on December 22, 2005. The March 17, 2006 dividend payment of $.5195 on the SPDRs Trust generated trading volumes of greater than 500,000 contracts for March 2006 calls with exercise prices of 126, 128, 129, and 130. What is clear from the table is that large dividends on calls with short times to expiration are ideal candidates for the dividend spread arbitrage strategy and that the dividend spread arbitrage activity can generate extraordinary call option trading volume.

5.3. Identity of arbitragers

With the link between call option trading volume and number of exercises on the day before ex-dividend clearly documented, we turn to identifying exactly who are the most active dividend spread arbitragers. To shed light on this issue, we first use the OCC exercise data which categorize the number of exercises of each option series each day

Table 10
Most actively traded call option series on day before ex-dividend during the sample period January 1996–April 2006

Ticker	Firm name	Day before ex-dividend	Dividend	Exercise price	Expiration date	Trading volume		
						t–2	t–1	t
MO	ALTRIA GROUP INC	3/10/2006	0.8000	70	3/18/2006	20,796	1,846,223	810
MO	ALTRIA GROUP INC	12/22/2005	0.8000	65	1/21/2006	826	1,823,892	5,428
MO	ALTRIA GROUP INC	9/12/2005	0.8000	65	9/17/2005	9,908	1,411,643	183
SPY	SPDR TR	3/16/2006	0.5195	130	3/18/2006	15,982	851,621	1,848
MWD	MORGAN STANLEY	7/12/2005	0.2700	50	7/16/2005	307	851,512	107
C	CITIGROUP INC	4/26/2006	0.4900	45	5/20/2006	854	779,462	2,219
SPY	SPDR TR	3/16/2006	0.5195	129	3/18/2006	8,815	662,990	543
MO	ALTRIA GROUP INC	6/10/2005	0.7300	60	6/18/2005	184	648,380	763
SPY	SPDR TR	3/16/2006	0.5195	128	3/18/2006	1,175	648,156	224
NEW	NEW CENTURY FINANCIAL CORP	3/28/2006	1.7500	40	5/20/2006	131	639,463	590
MO	ALTRIA GROUP INC	6/10/2005	0.7300	65	6/18/2005	1,601	596,109	843
MO	ALTRIA GROUP INC	12/22/2005	0.8000	55	1/21/2006	13	590,447	291
MO	ALTRIA GROUP INC	12/22/2005	0.8000	60	1/21/2006	14	587,761	220
MO	ALTRIA GROUP INC	3/10/2005	0.7300	60	3/19/2005	466	565,109	118
SPY	SPDR TR	3/16/2006	0.5195	126	3/18/2006	161	545,751	126
VZ	VERIZON COMMUNICATIONS	4/5/2006	0.4050	32.5	4/22/2006	816	543,096	2,752
MCIP	MCI INC	2/24/2005	0.4000	20	3/19/2005	3,222	539,482	716
BAC	BANKAMERICA CORP	11/29/2005	0.5000	45	12/17/2005	3,718	537,249	2,193
RAI	REYNOLDS AMERICAN INC	12/6/2005	1.2500	70	1/21/2006	0	529,465	0
T	AT&T INC	4/5/2006	0.3325	25	4/22/2006	0	520,318	0

The number of option classes (i.e., underlying stocks with quarterly dividends exceeding $.01) is 1,959, and the number of unique dividend payments is 42,602. The number of call option series with exercise prices below critical levels is 73,343.

by (a) customer, (b) market maker, and (c) member firm, and then sum across all ex-dividend exercise days each year during the sub-period July 2001–April 2006. A summary is provided in Table 11. The results are interesting in two important respects. First, as shown in Panel A, market makers are clearly the dominant dividend spread traders. Each year during the investigation period, they account for at least 68% of the exercise activity. Across all years, they account for 73.6%. The next most active spread trader is member firms, at 23.1% across all years. Customer exercise activity pales by comparison, at 3.3% across all years. Second, in Panel B of Table 4, we see that dividend spread trading activity continues to increase at a rapid rate. Average monthly numbers of exercises are relevant since the totals in Panel A reflect different numbers of months in each year. In 2001, five months of exercise data are available.[25] The numbers of months in 2002 through 2006 are 10, 12, 12, 12 and 4, respectively. Dividend spread trading involved an average of about 156,967 exercises in 2001, and it rose at an increasing rate to 4.9 million in 2005. Indeed, the acceleration continued into 2006.

[25]Recall that in Section 2 we noted that the OCC was unable to recover certain months of exercise data from their historical files.

Table 11
Number of exercises of call options on day before ex-dividend by customers, market makers, and member firms during the sample period July 2001–June 2005

Panel A: Total number of exercises on day before ex-dividend each year

Year	No. of ex-dividend exercise days	Number of exercises by				Proportion of total exercises by		
		Customers	Market makers	Firms	Total	Customers (%)	Market makers (%)	Firms (%)
2001	504	28,331	597,039	159,467	784,837	5.84	75.84	18.32
2002	1,574	104,454	2,266,499	739,418	3,110,371	4.31	74.06	21.63
2003	3,252	1,061,061	11,007,488	3,197,771	15,266,320	7.80	72.59	19.62
2004	4,452	1,027,483	17,396,521	4,999,860	23,423,864	6.29	70.03	23.68
2005	4,032	1,486,637	44,112,660	13,379,493	58,978,790	5.94	70.34	23.72
2006	864	365,962	14,800,606	5,848,603	21,015,171	10.05	68.64	21.30
Total	14,678	4,073,928	90,180,813	28,324,612	122,579,353	3.3	73.6	23.1

Panel B: Average number of exercises per month on day before ex-Dividend each year

Year	No. of ex-dividend exercise days	Number of exercises by			
		Customers	Market makers	Firms	Total
2001	504	5,666	119,407	31,893	156,967
2002	1,574	10,445	226,649	73,941	311,037
2003	3,252	88,421	917,290	266,480	1,272,193
2004	4,452	85,623	1,449,710	416,655	1,951,988
2005	4,032	123,886	3,676,055	1,114,957	4,914,899
2006	864	91,490	3,700,151	1,462,150	5,253,792

Panel A contains the total number within each year. Panel B adjusts for the fact that the number of months in which exercise data were available (i.e., 5 in 2001, 10 in 2002, 12 each in 2003, 2004 and 2005, and 4 in 2006).

The dominant role of market makers is also evident in volume statistics. Fig. 2 illustrates the fraction of trading volume of the different types of traders on ex-dividend days and on other days. While market makers are involved in 46% of trades on a typical day, they are involved in 67% of trades on the days before an ex-dividend day.

Interestingly, while the evidence of Tables 9 and 11 clearly points to extraordinary growth in dividend spread trading in recent years, Table 7 shows that the pool of funds available from calls that go unexercised on the day before ex-dividend is holding steady. What this implies is that, while the profitability of the strategy is declining, it remains profitable. Indeed, in an apparent attempt to ensure that the strategy (and its attendant trading volume) continues to grow, certain exchanges are capping transaction fees on dividend spreads at a fixed dollar amount, thereby promoting the use of large order sizes and increasing, albeit artificially, market share. Panel A of Fig. 3 shows the breakdown of call option trading volume by options exchange on a typical day during the year ending April 2006. The ISE and CBOE had the largest market shares—31% and 30%, respectively. The PHLX, PCX, and AMEX each have about a third of the volume of the ISE or CBOE. On the day before ex-dividend, however, market shares are dramatically reapportioned, with the PCX at 45% and the PHLX at 30%. So, while the PCX and

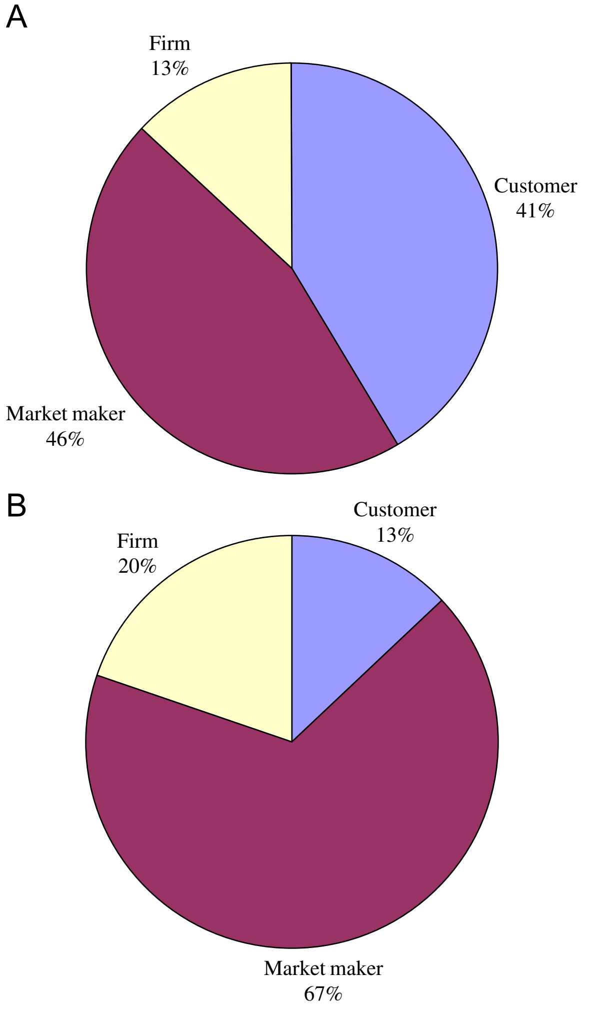

Fig. 2. Proportion of total call option trading volume by market participant during the year May 2005–April 2006. (A) All days other than day before ex-dividend day, (B) Day before ex-dividend day only.

PHLX normally garner about 22% of call option trading volume, they have 75% of the volume on the days before ex-dividend. This situation arises for two reasons. First, these particular exchanges cap fees on dividend spreads. Second, market makers on the trading floor continue to account for a significant proportion of trading volume on these exchanges. Conducting dividend spread arbitrage requires that market makers pre-arrange large trades at a price between the prevailing bid/ask quotes. Such trading is difficult, if not impossible, to execute in an electronic trading environment. On the other hand, the trading volume on the ISE, normally the most active options exchange, falls to 7% on the day before ex-dividend. As noted earlier, the ISE has no fee cap and is a fully electronic exchange.

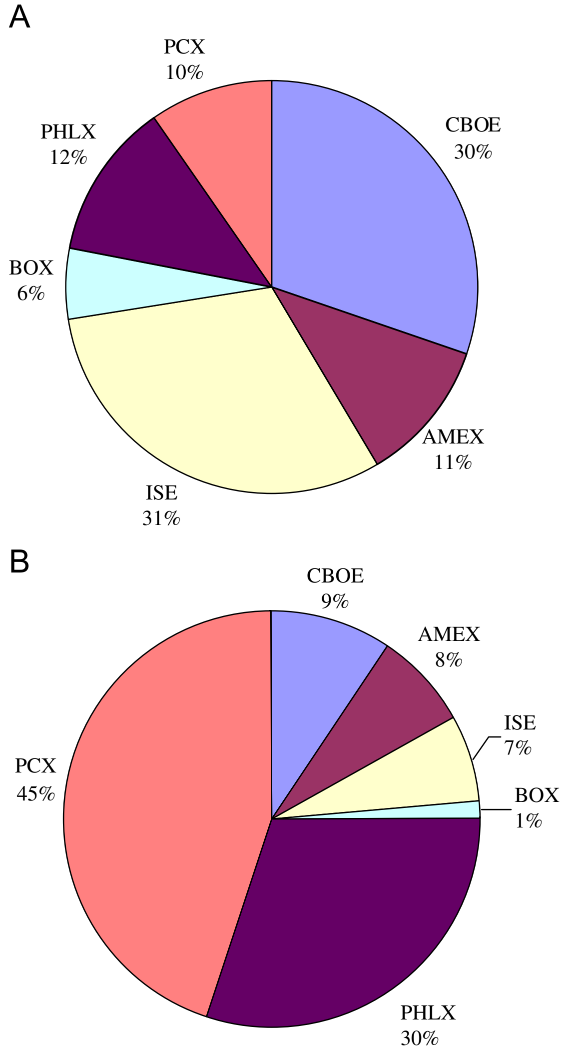

Fig. 3. Proportion of total call option trading volume by exchange during the year May 2005–April 2006. (A) All days other than day before ex-dividend day, (B) Day before ex-dividend day only.

6. Policy issues

Our analysis raises a number of important issues. First, why do call holders fail to exercise? Our analyses indicate that the explanations are twofold. The first is that the costs of trading options—the bid-ask spread and commissions—are substantial. In particular, we find that typical call option spreads are more than eleven times higher than the underlying stock spreads for options that should be exercised on the day before ex-dividend during our sample period, January 1996–April 2006. While option spreads have declined somewhat as a result of increased competition, reduced tick size and the Justice Department's push for multiple listing, the bid-ask spread in options remains quite large.

In addition, commission rates, particularly for exercising options, can be significant. Nevertheless we find that about 27% of the money left on the table from failure to exercise cannot be explained even by the highest trading costs, while another 40% is inconsistent with reasonable trading costs. Failure to exercise in many cases implies that call holders are unaware of the desirability of early exercise, lazy in the monitoring of their positions, and/or are simply irrational. In the interest of market integrity, exchanges and brokers should make a greater effort to educate customers and provide guidance on early exercise before ex-dividend days.

A second set of issues has to do with the extraordinary call option volume generated by arbitragers. First, some suggest that the high volume imposes greater operational risk in the marketplace. While the number of contracts traded is large, however, any disruption would be attributable to the number of trades (i.e., the number of players in the game) rather than the number of shares traded, and there are exchange incentives to have relatively few large traders. Second, the huge volume distorts the true meaning of volume statistics published by certain option exchanges that encourage dividend spread arbitrage trading. The volume is not related to any underlying purpose and reflects simply the activity of traders buying and selling exactly the same contracts, akin to wash sales.

Third, are there "fairness" issues surrounding dividend spread arbitrage? The effect of large professional volume is to reduce the probability of non-assignment of other call sellers who have been there for some time. Is it "fair" to retail short call positions to have their gains appropriated by professional arbitragers? Furthermore, retail customers cannot engage in the strategy since they incur significant trading costs, mostly from the option's bid/ask spread. Market makers, on the other hand, can prearrange trades at the spread midpoint. With such a trading cost advantage, market makers are reaping profits at the expense of customers. As option spreads fall, customers will be on a more equal footing; however, option spreads continue to be significantly higher than spreads in the underlying stock.

All of this is to say that, perhaps, certain changes in market practice might be warranted. The first is position netting. The market maker's (i.e., arbitrager's) ability to capture the gains arises because long call and short call positions in a given account are not netted before exercise. If positions were netted, arbitrager exercises and assignments would be zero since they hold identical long and short call positions. Netting by the OCC is usually not possible because individual accounts are not identified. Only market maker accounts are individually identifiable by the OCC. Netting could be accomplished by each clearing firm with respect to its own customers, but firms would have to be required to do so by the regulatory authorities. But, even if netting were mandatory, it is likely that arbitragers would modify their playing of the game to avoid the effects of netting. Rather than buy and sell the same option series, they would use options with different exercise prices or hedge their short option position in the stock market.

The second change is increasing the fees paid by market makers on dividend spread arbitrage positions. Since trades are consummated at bid/ask midpoints, the market maker avoids the option spread. In addition, his exchange fees on the trades are capped. The exchange is in a dilemma. By capping fees, some exchanges (currently the AMEX, CBOE, PCX and PHLX) attract greater trading volume than they would otherwise have and appear to boost their market share. While the trading volume associated with dividend spread arbitrage and its impact on market share is, in fact, illusory, it is not clear that one should impose increased fees to dispel the illusion.

7. Summary and conclusions

In the US, exchange-traded options are unprotected from cash dividend payments on the underlying stock, so it may become optimal to exercise deep in-the-money call options just prior to the ex-dividend day. In this study, we examine the extent to which option holders fail to exercise their call options on the day prior to an ex-dividend day when it is optimal to do so. Using a sample of call options on stocks with quarterly dividends of at least a penny per share during the period January 1996–April 2006, we find that more than half of outstanding long positions remain unexercised when they should be exercised. We estimate that this failure to exercise has caused call option holders to lose over $491 million over this 10+ year period. Some of that loss can be attributed to transaction costs, but a substantial portion is attributable to call option holder ignorance of call option mechanics, laziness in the monitoring of their positions, or, simply, irrationality. Perhaps greater effort by exchanges and brokers in providing guidance on exercise prior to ex-dividend days would mitigate the failure to optimally exercise.

The fact that so much money is left on the table by call option holders who fail to exercise optimally on the day before ex-dividend has not gone unnoticed and has given rise to dividend spread arbitrage. On the day before ex-dividend, the arbitrager buys and sells a large (relative to the previous day's open interest) but equal number of deep in-the-money calls. At the end of the day, he exercises the long positions and waits to be assigned delivery on the short positions. Since the OCC uses random assignment of exercise, a fraction of the arbitrager's short position goes unassigned, allowing him to capture the dividend when he covers his open position the following morning. We show that this trading is so prevalent that the arbitragers overall capture virtually all of the money left on the table—money that belonged to short call option holders on the day before. We also show that the dominant dividend spread arbitragers in the marketplace are market makers, accounting for more than 73% of the activity. Member firms account for about 23%.

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