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The Ex-Dividend Day Behavior of Option Prices*

It is well known that the price of a share of common stock is expected to drop around the ex-dividend day. Since call options written on such underlying shares are not protected against dividend payment, a question arises as to the behavior of the prices of call options around the ex-dividend day. Assuming a rational exercise policy on the part of investors, it can be demonstrated that the price behavior of American call options around the ex-dividend day should not be different from that on any other arbitrarily chosen day. However, our empirical analysis using both parametric and nonparametric methods indicates that, perhaps because of a "wrong" exercise policy on the part of investors, abnormal returns are observed in certain cases. This finding casts some doubt on the presumption of efficiency of the American call option market around the ex-dividend day.

I. Introduction

A security purchased at the opening of trade on the ex-dividend day does not include a claim to the dividend announced earlier, yet if purchased on the previous day (the last cum-dividend day) it does. Thus, the price of a security that goes ex-dividend is expected to drop in this time interval. The expected price drop around the ex-dividend day has been compared to the dividend per share in various past studies (Campbell and Beranek 1955; Durand and May 1960; Elton and Gruber 1970; Kalay 1982). The documented behavior of stock prices around the ex-dividend day seems to be consistent with market efficiency, that is, it provides no profit opportunities. An interesting question that arises is whether the discontinuity in the stock price carries over to call options on the stock with similar implications for market efficiency.

Because call options are unprotected against payment of dividends, their pricing has to take into account the change in the value of the underlying asset around the ex-dividend day. This point has been recognized in the literature since

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the original contribution in this area by Black and Scholes (1973). For the case of a European option on a stock that pays dividends continuously, the valuation relationship derived by Merton (1973) is a simple modification of the Black-Scholes model, with the riskless rate of interest adjusted by the rate of dividend payment. Roll (1977) analyzes American call options on a stock with known discontinuous future dividends and points out that there is a trade-off between the cost of early exercise of the option (i.e., the forgone call premium) and the expected drop in the value of the underlying asset, against which the option is unprotected. In the context of the Black-Scholes model, Roll identifies the condition for early exercise and provides a valuation relationship for the unprotected American call option.[1]

In this paper, we investigate the ex-dividend day behavior of American call options, both theoretically and empirically. On a theoretical level, we analyze the ex-dividend day price behavior of these options to investigate whether, given the discontinuity in stock prices, profit opportunities are implied. In particular, we consider the relationship between the call option prices and the prices of the underlying stock, both assets at any point in time, as well as the conditions under which both assets earn no more than their respective equilibrium rates of return. We show that in the absence of transaction or exercise costs and assuming rational exercise on the part of investors, the ex-dividend day behavior of American call options should not differ from their behavior on any other, arbitrarily chosen, day. Similarly, European call options should exhibit no unusual behavior.

On an empirical level, we investigate the ex-dividend day behavior of American call options, which, given "wrong" decisions by holders of options, can yield abnormal returns to a trader. This test of market efficiency differs from most others since one does not have to assume a specific valuation model and test a joint hypothesis—the validity of the valuation relationship and market efficiency. In particular, it is not necessary to rely on the Black-Scholes model, which uses the twin assumptions of lognormality of returns and continuous trading.

Specifically, in the method used here, the returns on the option around the ex-dividend day are compared to those on a randomly selected day. It should be noted that we make no assumption regarding the process generating returns on the underlying stock or the call option written on it, other than the stationarity of the latter process.

Section II of the paper analyzes the conditions for no profit opportunities to exist in the markets for call options and their underlying stocks

1. Geske (1979) models the call option directly as a compound option and provides an alternative derivation of the valuation relationship. On a related issue, Galai (1978) explores the boundary conditions for American call options with known future dividends.

around the ex-dividend day. Section III provides a description of the data, the methodology, and the results. The last section deals with implications for market efficiency and relates the observed empirical regularities to the basic theory.

II. The Conditions for No Profit Opportunities and Call Option Prices around the Ex-Dividend Day

Since dividend announcements precede the ex-dividend day, the dividend per share to be paid, D, is known with certainty prior to this date. The price per share of the stock is expected to drop by some fraction, a (assumed to be known with certainty),[2] of the dividend per share on this date.[3] By definition, at time E, the moment the stock goes ex-dividend,

$$C_E = S_E - X + P_E, \tag{1}$$

where C_E and P_E are the prices of the call option and the call premium over parity, respectively, and X is the exercise price. The cost of early exercise of a call option is P_E, which is nonnegative to prevent arbitrage. It follows, for a given dividend payment, that rational investors would exercise a call option before maturity only at the last cum-dividend day. On that day, the benefit from early exercise (ignoring the risk-adjusted returns on the short interval of time between the two days) is equal to the expected reduction in the stock price, aD. In other words, rational investors would exercise their options on the last cum-dividend day if the expected stock price drop is larger than the expected premium on the ex-dividend day, that is, $\overline{P}_E < aD$. The expected premium on the ex-dividend day depends on several factors, such as the stochastic process generating stock prices, the depth in the money of the option, the riskless rate of interest, and the time to maturity. In general, $\overline{P}_E$ may be less than aD.

The magnitude of the dividend to be paid is known with certainty on the last cum-dividend day. The option price on that day should reflect the expected drop in the stock price on the following day such that the expected option price on the ex-dividend day is equal to (again, ignoring the risk-adjusted return between the cum- and ex-dividends days) the option price on the last cum-dividend day, C; that is, $C_C = \overline{C}_E$. If the call premium at time C is nonnegative, $P_C \geqslant 0$, the expected premium on ex-day is not less than the expected price drop, $P_E \geqslant aD$.

2. The assumption of certainty with respect to a is of no great significance. The analysis would be similar if a were uncertain, except that cumbersome notation would be introduced regarding the expectation of a and its statistical relationships with the cum-dividend stock price S_C and D.

3. Past studies by Elton and Gruber (1970) and Kalay (1982) document a drop in the stock price on the ex-dividend of, on average, approximately 75% of the dividend per share.

The implications of the analysis above for the behavior of option prices around ex-dividend days are obvious. Options that are deep in the money and close to maturity, whose premiums over parity are small and, in particular, with $\bar{P}_t < aD$, would be exercised on the last cum-dividend day. In other words, assuming costless and rational early-exercise decisions by investors, only those options for which $P_t \geq aD$ would be traded on the ex-dividend day of the underlying stock, the other options being exercised early.[4] The lack of profit opportunities around the ex-dividend day leads to the following prediction: If investors follow a rational exercise policy, the ex-dividend day behavior of American call options should not differ from any other, arbitrarily chosen, day.

III. Data, Methodology, and Results

The Data

The closing prices of American call options whose underlying stocks went ex-dividend were collected from the files of *Rapidata*, a commercial data service. This data service provides daily prices of, among other securities, stocks and call options for the most recent 66 days. The data are updated continuously by the service with 1 day's data being added and dropped, respectively, at the end of each trading day. In this study, the data used include daily call option prices for the period between April 1979 and June 1980. The resulting sample consists of 4,464 American call options written on 189 stocks. In addition, the relevant ex-dividend dates, dividends per share, and exercise prices of the options were also collected from *Rapidata*. The number of options in our sample exceeds by far the number of stocks, since in almost all cases there are several options written at various exercise prices and maturity dates on the same stock. This, of course, leads to statistical dependence in their realized returns: the effect of payment of dividends on the stock may be similar for all the options. In order to avoid this problem of statistical dependence, we randomly chose one option from each stock. The resulting subsample contains 316 options.[5]

The Computation of Standardized Excess Returns

The hypothesis of efficiency of the call option market is tested in the following manner. First, we analyze the behavior of call option prices

4. The case of European call options is interesting since they cannot be exercised early. It turns out that in the absence of transaction costs the condition for no profit opportunities is for the stock price to drop by an amount exactly equal to the dividend per share. (See Kalay 1982; Kalay and Subrahmanyam 1982.)

5. Since the maximum life of each option is 9 months and the length the period covered in this study is 15 months, there are more options than stocks even at the same exercise prices.

on a randomly selected day. For each option, the daily expected rate of return is estimated using 66 daily prices surrounding (but excluding) the ex-dividend day, taking care to include only days in which the option has a positive trading volume. This selection criterion ensures that only actual trading prices are used.[6] Thus, assuming stationarity of the process generating returns, the daily return of option j for day t is defined as

$$R_{j,t} = \frac{(C_{j,t} - C_{j,t-1})}{C_{j,t-1}}, \tag{2}$$

where $C_{j,t}$ is the price of the call option at the end of day t. The expected daily return of option j is

$$\bar{R}_j = \frac{1}{T_j} \sum_{t=1}^{T_j} R_{j,t}, \tag{3}$$

where T_j is the number of days (out of the 60 days surrounding the ex-dividend day) on which the volume of trade in option j is positive. Similarly, the standard deviation of the daily return is defined by

$$S_j^2 = \frac{1}{T_j} \sum_{t=1}^{T_j} (R_{j,t} - \bar{R}_j)^2. \tag{4}$$

Next we define the standardized excess return (SER) of option j for time t to be[7]

$$SER_{j,t} = \frac{(R_{j,t} - \bar{R}_j)}{S_j}, \tag{5}$$

where $R_{j,t}$ is the realized daily return on option j for day t and S_j is the estimate of the standard deviation of the daily returns of option j, computed using the same data. For example, if the distribution of option returns is normal, the distribution of SER_j is standard normal.[8]

To analyze the behavior of option prices on a typical day, we select randomly an SER for one day for each option, $SER_{j,t}$. The resulting sample of 316 observations excludes the ex-dividend days around which the SER's are calculated. We follow a similar procedure in

6. Early exercise is not considered a part of the trading volume according to both Chicago Board Options Exchange (CBOE) and American Stock Exchange (AMEX) rules.

7. A similar method of calculating excess returns is used by Masulis (1980) and shown by Brown and Warner (1980) to be as robust as the traditional definition, which uses the market model as a specification of the underlying returns-generating process. The major advantage of these methods is that they require no more than stationarity of the underlying stochastic process.

8. However, a Kolmogorov-Smirnov one-sample test led to rejection of the null hypothesis of the normality of the SER's at the 1% level. The maximum difference between the cumulative probability distributions of the sample and the standard normal is 17.83%, which is significant at the 1% level.

studying the behavior of option prices on the ex-dividend day and collect a sample of rates of returns on the ex-dividend day. To ensure that the analysis is restricted to transactions that could actually be executed, the sample includes only those options that have been traded on both the ex-dividend day and the last cum-dividend day. Furthermore, the selection ensures that the options included had not been completely exercised on the last cum-dividend day. Hence, the resulting subsample does not contain cases in which the entire supply of the particular option has been exercised on the last cum-dividend day and a new supply of the same option created the next day.[9] Therefore, the rates of return documented here represent real trading possibilities.

The standardized excess return on the ex-dividend day ($SERX$) for option j is estimated as follows:

$$SERX_j = \frac{(R_{j,0} - \bar{\bar{R}}_j)}{S_j}, \tag{6}$$

where $R_{j,0}$ is the realized return on option j on the ex-dividend day, and $\bar{\bar{R}}_j$ and S_j are defined as in equations (3) and (4).

In our sample there are 599 $SERX$'s, which is somewhat larger than the size of the SER sample since many options experienced more than one ex-dividend day during the period studied. The samples of the SER's and $SERX$'s generated from equations (5) and (6) are the basis for the empirical tests below.

Nonparametric Tests and Results

Distributional tests. We saw in our earlier analysis that if investors follow a rational exercise policy, the distribution of the $SERX$'s should not differ from the distribution of the SER's. Since we do not wish to make any distributional assumptions about the SER's and $SERX$'s, we resort to nonparametric tests.[10] The relevant nonparametric test of our hypothesis is the Kolmogorov-Smirnov two-samples test, the results of which are tabulated in table 1. The cumulative probability distribution (CPD) of the SER is presented in the first row, while the second row contains the CPD of the $SERX$. If the two samples had been drawn from the same population, the CPD of both samples would have been fairly close to each other. Thus, a large enough difference between them is evidence in favor of rejecting the null hypothesis. The critical value at the 1% level when $N_1 = 316$ and $N_2 = 599$ is 11.4%, while the

9. This selection procedure does not exclude the possibility that, in some cases, the options have been "almost" totally exercised on the day prior to the ex-dividend day. We address this issue later by examining the behavior of the supply of options (i.e., the open interest) around the ex-dividend day.

10. We tested the null hypothesis also using standard parametric methods. The conclusions of the parametric tests involving the central limit theorem were essentially similar to those reported here.

TABLE 1 **A Comparison between the Cumulative Probability Distribution of the Standardized Excess Returns on a Random Day[a] (*SER*'s) and on the Ex-Dividend Day (*SERX*'s) (%)**

	$x \leq -3.5$	$-3.5 < x \leq -2.5$	$-2.5 < x \leq -1.5$	$-1.5 < x \leq -0.5$	$-0.5 < x \leq 0.5$	$0.5 < x \leq 1.5$	$1.5 < x \leq 2.5$	$2.5 < x \leq 3.5$	$3.5 <$
Cumulative probability distribution of the *SER*'s on a random day	1.3	1.6	1.9	13	80.7	96.8	99.7	100	100
Cumulative probability distribution of the *SERX*'s on the ex-dividend day	0.5	1.3	6.3	27.5**	79.6*	93.3	96.8	100	100

[a] The critical value of the Kolmogorov-Smirnov two-sample test for $N_1 = 316$ and $N_2 = 599$ at the 1% level is 11.4%.
* The maximum deviation from the standard normal distribution is 10.45%. Thus, normality of the *SERX*'s is rejected at the 5% level.
** The maximum difference is 14.5%. Thus, we reject the null hypothesis at the 1% level.

maximum difference between the two CPDs is 14.5% (see col. 5). Hence, the null hypothesis is rejected at the 1% level.

Recall that the prediction of our analysis is that significantly negative *SERX*'s could occur only when the option holders make wrong decisions as to the timing of the exercise. The only case in which a decision needs to be made is, as discussed in Section II above, when the option is deep in the money close to maturity such that its expected premium, $\bar{P}_E$, is less than the expected price drop, aD. To investigate this, we divide the sample into the four groups detailed below:

1. out-of-the-money options written on stocks whose dividend per share is less than 40 cents;[11]
2. out-of-the-money options written on stocks whose dividend per share is greater than or equal to 40 cents;
3. in-the-money options whose premia on the last cum-dividend day are greater than zero; and
4. in-the-money options whose premia on the last cum-dividend day are nonpositive.

The last group contains options which should have been exercised on the last cum-dividend day in the absence of exercise costs. Since $\bar{P}_E$ is not observable at time C, the operational classification is based on $P_C \leq 0$, which is, of course, similar to the classification yielded by the criterion $\bar{P}_E \leq aD$.

To investigate the cause of the departure between the two samples, we compare the *SERX*'s in each case with the sample of *SER*'s on a random day for each group. The results are detailed in table 2. Rows 2–5 list the four subsamples and contain their CPDs. The maximum difference between each of those and the CPD of the *SER*'s on a random day is provided in column 12.

As expected, we fail to reject the hypothesis that the sample of *SERX*'s for out-of-the-money options written on a stock whose dividend is less than 40 cents, and the sample of *SER*'s on a random day is drawn from the same population. Similarly, as expected, we find the CPD of the *SERX*'s for out-of-the-money options associated with larger dividends (i.e., greater than or equal to 40 cents) to be insignificantly different from the CPD of the *SER*'s on a random day.

More important, the hypothesis that the sample of *SERX*'s of in-the-money options whose premium on the last cum-dividend day is less than or equal to zero, and the sample of *SER*'s on a random day is drawn from the same population, is rejected at the .01 level. This result makes sense, since in these cases the options should have been exer-

11. The median quarterly dividend paid on stocks traded on the New York Stock Exchange is approximately 40 cents.

TABLE 2 **A Comparison between the Cumulative Probability Distributions of the Standardized Excess Returns on a Random Day (*SER*) and on the Ex-Dividend Day for the Four Subsamples ($SERX_i$, i = 1, 2, 3, 4)**

The Sample	Same Size	$x < -3.5$	$-3.5 < x < -2.5$	$-2.5 < x < -1.5$	$-1.5 < x < -0.5$	$-0.5 < x < 0.5$	$0.5 < x < 1.5$	$1.5 < x < 2.5$	$2.5 < x < 3.5$	$3.5 < x$	Maximum Difference[a]
SER's for a random day	316	1.3	1.6	1.9	13	80.7	96.8	99.7	100	100	0
SERX's for out-of-the-money options with dividends < 40 cents	34	0	0	2.9	29.4[b]	64.7	88.2	97.1	100	100	16.4
SERX's for out-of-the-money options with dividends ≥ 40 cents	59	0	0	3.4	20.3[b]	79.7	96.6	98.3	98.3	100	7.3
SERX's for in-the-money options whose premia on the cum-dividend day > 0	327	0.9	2.1	5.2	29.7[b]	75.2	92.0	96.3	98.8	100	16.7**
SERX's for in-the-money options whose premia on the last cum-dividend day ≤ 0	179	0	0.6	10.1	17.9[b]	90.5	96.6	97.8	99.4	100	14.9*

[a] The maximum difference between each of the samples and the random day sample.
[b] Notice that the maximum difference always occurs in this column.
* Significant at the .05 level.
** Significant at the .01 level.

cised cum-dividend. We also find that only this group has a probability distribution that is significantly different from the standard normal.[12]

Last, the hypothesis that the sample of *SERX*'s of in-the-money options whose last cum-dividend premium exceeds zero and the sample of *SER*'s on a random day are drawn from the same population is rejected at the 1% level. This result is somewhat surprising since, in this case, a decision on early exercise is unnecessary and negative returns are not expected. To the extent that the last cum-dividend premium may be measured with some error due to nonsynchronous trading in the stock and the option markets, this group may contain some options that should have been exercised. If so, they may partially explain this somewhat unexpected result.

In summary, the ex-dividend day behavior of American calls option prices differs significantly from their behavior on a random day. The source of the difference seems to arise from a subsample of in-the-money options whose last cum-dividend day returns of options appear to be lower than their returns on a random day. We now test whether the two samples differ in their central tendencies.

Median test. The nonparametric form of the null hypothesis is that the two samples—the sample of *SER*'s on a random day and the relevant subsample of *SERX*—have been drawn from a population with the same median, the median being a measure of central tendency in the present case. To perform the median test, we first determine the median of the combined sample (i.e., the median for all scores in both samples). Then we dichotomize both subsamples at the combined median and classify these data into four cells, based on the classification of the observation above or below the combined median in each sample. Table 3 depicts this classification. Columns 2 and 3 provide the number of observations above or below the combined median, respectively, for the *SER* on a random day. Columns 4 and 5 provide the same classification for the selected sample of *SERX*. If the two samples are drawn from a population with the same median, we should find each individual median fairly close to the median of the combined sample. Large differences would be evidence against the null hypothesis.

The first test compares the central tendencies of the entire ex-dividend day sample with the sample of *SER* on a random day. As presented in row 1 of table 3, there are 314 observations *below* the combined median in the ex-dividend day sample out of 599, while more

12. Using the Kolmogorov-Smirnov one-sample test, the maximum difference between the CPDs of the first three groups and that of the standard normal are 5.12%, 10.55%, and 7.05%, respectively. All these differences are insignificant at the 5% level. Hence, the probability distribution of the *SERX*'s of these three groups are insignificantly different from the standard normal. Only in the last group do we find the maximum difference (which is 20.85%) to be significant at the 1% level.

TABLE 3 A χ^2 Test of the Hypothesis that the Two Samples Are Drawn from a Population with the Same Median

The Sample	*SER*'s on a Randomly Selected Day ($N = 316$)		*SERX*'s for Selected Sample		χ^2 Value
	Observations above the Combined Median	Observations below the Combined Median	Observations above the Combined Median	Observations below the Combined Median	
1. Entire ex-dividend day sample ($N = 599$)	172	144	285	314	3.614
2. Out-of-the-money options with dividends < 40 cents ($N = 34$)	162	154	13	21	1.596
3. Out-of-the-money options with dividends ≥ 40 cents ($N = 59$)	162	154	25	34	1.237
4. In-the-money options whose premia on the last cum-dividend day ≥ 0 ($N = 327$)	184	132	138	189	15.87***
5. In-the-money options whose premia on the last cum-dividend day < 0 ($N = 179$)	196	120	52	127	48.39***

*** Significant at the .001 level.

observations in the random day sample are *above* the combined median (172 out of 316). Performing a χ^2 test, however, we find the χ^2 value to be 3.614 (see col. 6 in table 6), which is not significant at the 5% level.[13] Hence, consistent with the parametric tests, the nonparametric tests indicate that the median excess return on the ex-dividend day is not different from that on a randomly selected day.

Next, we divide the sample into four subgroups as detailed in rows 2–5 in table 3, repeating the test for each of them. As expected, we fail to reject the hypothesis that the samples of the *SERX*'s of out-of-the-money options with large and small dividends, respectively, and the sample of *SER*'s on a random day are drawn from a population with the same median (see rows 2 and 3 in table 3). Furthermore, the hypothesis that the median *SERX* of in-the-money options whose last cum-dividend premium is nonpositive is equal to the median *SER* on a random day is rejected at the .001 level. The χ^2 value in this case is 48.39. Obviously, this result is to be expected; the options contained in this group should have been exercised cum-dividend, as discussed earlier. Again somewhat surprising is the rejection, at the .001 level, of the hypothesis that the median *SERX* of in-the-money options, whose last cum-dividend premium is positive, is equal to the median *SER* on a random day (see row 4 in table 3). Since these options should not have been exercised, their behavior on the ex-dividend day should not differ from that on any other day. As in the case of the Kolmogorov-Smirnov two-sample tests, the possible explanation for this result is very likely to be the measurement error in the last cum-dividend premium, resulting in the misclassification of some observations.

IV. The Supply Side

The empirical evidence presented in the previous sections suggests that options which should have been exercised on the last cum-dividend day exhibit significantly negative excess returns if held during the cum-ex-dividend interval of time. In other words, the data imply that since the options in the sample all have positive trading volume during this period, at least in some cases the options that should have been exercised by rational investors have not been. The question remains, What fraction of such options remains unexercised during this interval of time? This information is important since it can be used as the basis for an estimate of the probability of early exercise on the last cum-dividend day. This probability estimate, in turn, has implications for market efficiency, since it is a crucial determinant of the profitability of trading around the ex-dividend day.

The importance of the probability of early exercise can be illustrated

13. For details on the transformation to a χ^2 test, see Siegel (1956), pp. 111–16.

by the following situation. Consider the case of a trader who expects the price of the unexercised option to drop by 5% in the cum-ex-dividend interval of time. Suppose further that his transaction costs are .5% of the option price. The trader would wait until the last minute of trade on the last cum-dividend day and sell the option short. If this option is not exercised he will cover his position the next morning and his net-of-transaction costs gain is expected to be 4.5%. The story, however, is not so simple. The Options Clearing Corporation of the option exchange receives exercise orders during the day and assigns them (randomly) to traders the next morning. Thus, our trader could be informed on the morning of the ex-dividend day that the option he wrote at the closing of the previous day has been exercised at that time. He would then incur the transaction costs without gaining the price drop. If, for example, the probability of early exercise on the last cum-dividend day is .9, the expected return of our trader is zero even though the price of the unexercised options drops by 5%. Therefore, if the probability of early exercise on the last cum-dividend day is high enough, an observed drop in the price of unexercised options may still be consistent with no profit opportunities.

An indirect estimate of the probability of early exercise on the last cum-dividend day can be obtained by comparing the open interest at the end of the ex-dividend day (i.e., the number of live contracts) to that on a randomly selected day. A significant reduction in the open interest around the ex-dividend day implies an increase in the probability of early exercise.

To estimate the probability of early exercise, daily data on open interest of all options traded on the Chicago Board Options Exchange (CBOE) and American Stock Exchange (AMEX) were collected from *Rapidata*. Since this data service maintains data on the open interest only for the last trading day, updating it daily for the entire sample period involves substantial costs. We were, therefore, forced to limit the sample period to June 16–July 30, 1981. To be included in the sample, each option had to have a complete data history on the open interest for the previous 25 trading days. This selection procedure resulted in a sample of 1,368 options each having 25 daily observations of open interest. From this sample, we separated those options whose underlying stocks had gone ex-dividend during the 25-day period. The resulting sample included 289 options, each having 25 daily observations of open interest.

Assuming that the stochastic process generating open interests is stationary, we estimated its mean and standard deviation making use of 20 daily observations, excluding the ex-dividend day and the 4 days surrounding it (i.e., excluding days $t = -2, -1, 0, +1$, and $+2$). The standardized excess open interest of option j at time t by

$$SEOI_{j,t} = (OI_{j,t} - \overline{OI}_j)/SDOI_j. \tag{7}$$

where $\overline{OI}_j$ and $SDOI_j$ are the estimated mean and standard deviation, respectively. The standardized excess open interests are averaged cross-sectionally in event time to get

$$Z_t = \overline{SEOI}_t = \frac{1}{N_t} \sum_{j=1}^{N_t} SEOI_{j,t}, \tag{8}$$

where N_t is the number of options for which $SEOI_{j,t}$ is computed for day t.

The results of the computations above are reported in table 4. The first column provides the index of the day in the event time relative to the ex-dividend day, day 0. Column 2 furnishes data on the z-statistics (i.e., the cross-sectional mean standardized excess open interests defined in eq. [8] above), with the t-statistics of the z for a particular day provided in the respective row of column 3.[14]

The evidence indicates that the open interest on the ex-dividend day and days just before and after is no different from that on a randomly selected day. For example, the t-statistic of the null hypothesis on the ex-dividend day (day 0) is 0.8005, that is, insignificantly different from 0 at the 5% level.[15]

Columns 4 and 5 relate to the same statistics as in columns 2 and 3 but refer only to options that are out of the money the day before the ex-dividend day. As expected from our previous analysis, the results are no different from those of the overall sample. More interesting, similar evidence was obtained for the two subsamples of in-the-money options. Columns 6 and 7 refer to in-the-money options whose premia on the day before the ex-dividend day are positive. Similarly, data for in-the-money options with negative premia are presented in the last two columns.

Contrary to our expectations, the analysis based on this sample indicates that the probability of early exercise on the days just prior to the ex-dividend day is no different from any other day, even for those options where early exercise may be warranted. Therefore, the documented discontinuity in option prices around the ex-dividend day seems to suggest the existence of profit opportunities to a trader.

14. The number of observations for each day in event time does not decrease monotonically as we move away from the ex-dividend day on either side of zero. This is so, first, because the ex-dividend dates are not uniformly distributed throughout the sample period, and second, because observations for a few days are missing.

15. According to the rules of the clearing corporations of both the AMEX and CBOE, premature exercises of call options are reflected in open interest data the following day. However, our enquiries with officials of the two exchanges indicate that it is possible for trading volume to be unmatched and lag by a few days. For this reason, we tested the null hypothesis not just for day 0 but for a few days before and after. We found no substantial differences in the results.

TABLE 4 The Behavior of the Standardized Excess Open Interest around the Ex-Dividend Day

Date in Event Time	Overall Sample (N = 289)		Out-of-the-Money Options (N = 148)		In-the-Money Option with Positive Premium on the Last Cum-Dividend Day (N = 61)		In-the-Money Option with Negative Premium on the Last Cum-Dividend Day (N = 80)	
	$\overline{SEOI_t}$[a]	t-Statistic[b]	$\overline{SEOI_t}$	t-Statistic	$\overline{SEOI_t}$	t-Statistic	$\overline{SEOI_t}$	t-Statistic
−5	−.1346	−.3912	.2035	.7096	−.4605	−.8478	−.3802	−.9693
−4	.2817	.5245	.5036	1.4920	.1314	−.0252	−.0660	−.3916
−3	.3134	.5943	.4653	1.3922	.2911	.1968	.0040	−.2628
−2	−.1456	−.4153	.1446	.5560	−.4418	−.8218	−.5362	−1.2560
−1	.3983	.7810	.5148	1.5214	.6201	.6540	−.0509	−.3638
0	.4072	.8005	.6185	1.7917	.4364	.3987	−.0432	−.3496
1	−.1218	−.3630	.1617	.6006	−.3654	−.7156	−.4257	−1.0530
2	−.0053	−.1067	.1870	.6665	−.0275	−.2460	−.3340	−.8843
3	.0675	.0534	.2331	.7868	.0869	−.0870	−.2447	−.7201
4	.0029	−.0888	.1260	.5076	.0228	−.1761	−.3143	−.8481
5	−.1441	−.4120	−.0335	.0915	−.2412	−.5431	−.2532	−.7358

[a] $\overline{SEOI_t}$ is the mean standardized open interest calculated as follows:

$$\overline{SEOI_t} = \frac{1}{N_t} \sum_{i=1}^{N_t} \left(\frac{OI_{j,t} - \overline{OI_j}}{SDOI_j} \right),$$

where $OI_{j,t}$ is the open interest of option j at the close of day t; $\overline{OI_j}$ is the estimate of the mean open interest of option j. $SDOI_j$ is the estimate of the standard deviation of the open interest of option j.

[b] t-statistics of H_0: $\overline{SEOI_t} = 0$.

IV. Conclusions and Implications for Market Efficiency

In the case of in-the-money options with nonpositive premia on the last cum-dividend day, we have found significantly negative excess returns around the ex-dividend day. Thus, a policy of selling short on the last cum-dividend day and repurchasing on the following day could earn significant excess return. If it does, this is a clear evidence of market inefficiency. However, we are somewhat doubtful about the possibility of an active trading rule that generates excess returns net of transaction costs. (Our submitting this paper for publication should be taken as evidence in support of this statement!) As has been noted by others (see Phillips and Smith 1980), the transaction costs of trading in the option market are high and most likely exceed the gains from the strategy that is suggested by the empirical results.

On the other hand, the evidence reported here regarding options with nonpositive premia on the last cum-dividend day is strong enough to raise some questions. Why do the holders of options not exercise them on the last cum-dividend day? By the same token, why does *any* buyer choose to buy these options on the last cum-dividend day rather than wait a day and, on average, buy them at a lower price? Finally, to the extent that a large trading population of investors exists, which has decided to trade in this time interval for reasons unrelated to the dividends, why does their consideration of the timing of trade not eliminate these negative returns?

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