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Price Fluctuations of Underlying Shares as Listed Options Expire

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Since 1973 when trading in listed options began on the Chicago Board Options Exchange (CBOE), there has been concern, see Nathan [10] and Lenzner [7], that option trading might influence the prices of the underlying common shares. Regulators apparently would consider it disruptive if option trading had any impact on the price of the underlying stock. If option trading moves the price of the underlying stock, the causality expected by investors would, in their view, be reversed. Stock price is supposed to be the prime mover, and option price is supposed to follow along. Presumably, the typical stock market participant evaluates share prices and believes that share prices respond to events affecting the company's prospects and not to short-term trading conditions occurring on the option exchange. An alternative view of this pricing process is that both option prices and stock prices respond to new information and that the options market is an additional trading arena in which new information can be worked into the structure of asset prices. The options market in this view is one more avenue for information to influence the pricing of financial assets. Thus, stock and options prices may influence each other in ways that speed the workings of financial markets. The issue for regulators is whether there are any impediments or biases in this price forming process.

A number of papers have addressed the influence of option trading on prices of the underlying shares and have found that there are certain systematic influences [3,4,5,12,13]. These studies are valuable and constitute the research antecedents to this study.

This study focuses on the influence of option trading on the price of the underlying stock only at the time option series expire. The inquiry does not examine the influence, if any, that option trading has on the price or total return of the underlying stock for most of the option's life. If option trading exerts influence all during an option's life, such influence may be stable and thus hard to detect even with a methodology that would compare option stocks with those without options. Also, the previous studies mentioned above have employed a total return approach; thus, the use of a different methodology may either enhance previous findings or, in the event previous results can not be replicated with the different approach, lead to a methodological dialectic.

By concentrating attention on trading activity at the time options expire, this study examines a period of alleged vulnerability in the price formation process. Market practitioners have alleged that option expiration may influence the price of the underlying shares [6,9]. Such arguments are usually institutional in nature; statistical evidence on the point has been mixed. A recent study could neither accept nor reject that there was some systematic pricing bias at option expiration time [12].

The present study examines the prices of the underlying shares on the date that option series expire. It employs a methodology that compares observed stock behavior with an hypothesized expected pattern. The advantage of this approach is that it avoids the problems associated with a test group and a control group. The construction of a control group consisting of stocks similar to a group of stocks with listed options would be a difficult, if not impossible, task.

The complexity of price behavior around option ex-

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piration time is the primary motivation for this study. There are, in addition, institutional developments that may add to the complexity of price behavior or undermine earlier explanations. These include:

1. Option trading volume is now higher than it was when the previous studies were conducted [2].
2. Trading in listed puts has begun and has gained popularity. The number of stocks with listed puts has risen rapidly in the past two years [8]. This development by itself casts doubt on the present reliability of previous studies since countervailing pressures may now exist between puts and calls.
3. The emergence of short selling is hedged with puts and calls, as practiced by brokerage firms. This form of trading endeavors to lock in arbitrage profits as an option series approaches expiration [6]. Evidently, if this trading attained high volume relative to the volume generated by other market participants, i.e., those buying to selling the stock on its merits as an unhedged investment, such trading could influence the share price and cause it to fluctuate in patterns that perhaps are predictable or, in any event, different from previously observed patterns.

BACKGROUND

Listed options trade in series, with a new series coming on the board (into existence) every three months. Each series includes options, both puts and calls, at various strike prices. These series are labeled by month of expiration, e.g., the January series. An option series expires on the Saturday following the third Friday in the expiration month.

Trading in options continues up to one hour before the market closes on the last day of the option's life. Individual investors holding expiring in-the-money calls (those calls whose strike price is less than the current market price) may exercise the calls if they wish to own the underlying stock, but more commonly they sell their calls to floor traders. These traders exercise the expiring calls by calling the 100 shares that each call covers while simultaneously selling back the 100 shares on the stock market. To make a profit on this transaction, traders offer to buy in-the-money calls at a discount from their theoretical value, i.e., the difference between the stock's market price and the option's strike price. Holders of these calls willingly accept the demanded discount to avoid excessive trading commissions that ensue to an individual calling in the stock.

Holders of expiring in-the-money puts can also exercise their puts by purchasing the underlying stock and delivering it to the put writer, but again it is commonly more profitable for them to sell the expiring put to a floor trader who carries out the transactions. Again, working through floor traders minimizes transaction costs to the investor. Floor traders compete for these arbitrage trades so the individual receives almost all of the difference between the market price and the put's strike price.

It is clear from the above discussion that on the last trading day of an expiring series of options there may be a large volume of transactions in the shares of underlying stock. For each in-the-money call there will be a 100 share sale, unless some option holders want to take delivery and own the stock. Likewise, for each in-the-money put option there will be a 100 share purchase, unless some holders already own the shares and intend to deliver those. Normally, option trading activity is heavier in the puts and calls with strike prices adjacent to the current market price. Holders of options with strike prices farther from the current market price generally "close out" their positions prior to expiration, although some positions always exist until the last possibel moment. Out-of-the-money options, of course, expire worthless.

Transactions in the underlying shares on the last trading day of the expiring option series may be divided into two groups. This distinction, which is made for heuristic purposes, is as follows. Spontaneous transactions are those initiated by parties who have no participation in the options market. These are trades that would have occurred even if no option series had expired. Induced transactions are those initiated by parties whose objective is to liquidate an in-the-money option. Obviously, a person who wants to liquidate an in-the-money call may call the shares and sell them to another person who is impressed with the company and wants to own shares in it. It would, therefore, be very difficult in practice to differentiate spontaneous from induced transactions. Nevertheless, there may be some increase in trading volume on expiration day that would be attributed to option exercise. (While covered option writing may limit the increase in volume, it would appear that the majority of option activity is in the naked category.) The conventional wisdom among traders is that this increase in volume somehow strains the specialists' capacity to maintain an orderly market and hence permits stock price fluctuations that are different from what one would expect if there were no option trading [9]. These fluctuations would constitute temporary mispricing, according to the conventional wisdom among traders. Some would assert that certain individuals have been able to profit from this mispricing [9].

This paper investigates whether mispricing of the underlying shares takes place on the day an option series expires. The research question is: On the day when an option series expires, do the underlying shares fluctuate in a way that is different from the way they could be expected to fluctuate if there were no option expiration?

To answer this question it is first necessary to characterize share price fluctuations as they ordinarily occur in the absence of any institutional interference, distortion, or manipulation. As a first approximation,

the literature, see Cootner [1] and Osborne [14], suggests that day-to-day price changes will be distributed symmetrically about zero. This distribution will be truncated at the left tail since stock price cannot become negative. Apart from that caveat, there can also be a trend to stock price fluctuations, and, in addition, they will respond to new information. If on a given day the stock price is far above zero, it may be a suitable approximation to describe share price fluctuations as mean zero, with equal probability of the share price rising or falling by a given amount from its current price.

This characterization of stock price fluctuating as a symmetric mean-zero distribution would not be suitable for all research designs. For this design it may be appropriate because the data are cross-sectional, which means that trends in the prices of individual shares is not a major concern. In addition, all the share prices in the sample are many standard deviations away from zero, so the asymmetry of the lognormal distribution was not considered to constitute a serious problem. Finally, new information may have affected some stocks in our sample negatively and some positively; consequently, the impact of new information probably does not induce major systematic asymmetry into the sample used in this research.

DIVERGENCE PRICES

At the time an option expires, the underlying stock price is usually between two option strike prices, one above and one below the current market price. This statement was verified for the issues in the sample. These strike prices bracket the stock price. Where the stock price was was computed in this five-dollar bracket. Specifically, divergence prices were calculated that equal the difference between the current market price and the nearest option stock price.

$$\text{Divergence Price}_{ij} - \text{Market Price}_{ij} - \text{Strike Price}_{ij} \quad (1)$$

where j represents stock issue and where i represents the month and year for which New York (NYSE) or American (AMSE) Stock Exchange and CBOE and American Exchange (AE) option price data are available.

At most, divergence prices are \$2.50 above or \$2.50 below the nearest strike price. High priced issues with \$10 option spreads were not in our sample. Most NYSE and AMSE issues trade in eighths of dollars; therefore, divergence prices in eighths range between −20 when the stock price is \$2.50 below the strike price and +20 when the market price is \$2.50 above the strike price, thus producing 41 different categories. Each unit change in divergence price corresponds to an eighth of a point move in the underlying stock.

In total, twelve option expiration dates were used. Each option expiration date was considered as an independent trial in a stable, trendless generating process. That is, it was assumed that institutional factors were the same at each expiration date. (Later this assumption was questioned because the advent of put trading appeared to have some influence.) It was also assumed that long-run trend in equity prices could be ignored since the computation of divergence prices would tend to eliminate trends. Finally, it was assumed that on some of the expiration dates equity prices rallied and on some they fell and that these effects cancel each other out. Of the 48 monthly expiration days within 1978-1981, equity prices, as measured by the Dow Jones Index, rose 26 times and fell 22 times. Moreover, over the 48 months, the average change in the Dow Jones index on expiration was −\$0.60. Thus, the average decline was slightly stronger than the average rally, but overall the evidence supports the assumption of a neutral impact.

What distribution should this sample of divergence prices be expected to have? This study hypothesizes a distribution for these divergence prices and then uses a parametric test to determine whether they fit the hypothesized distribution.

As stock trading goes on during the days preceding option expiration, the prices of underlying shares fluctuate according to new information. New information arrives randomly. In view of this, let us consider an option stock in the sample that closed between 40 and 45 on the Friday an option series expired. There are options with 40 and 45 strike prices, and there may be other options with higher and lower strike prices. In many cases the stock price may have been higher than 45 and lower than 40 during the life of the option series that is expiring. The stock price may have risen to reach its present level, or it may have fallen to its present level.

Since this study assumes no prior information, the view is taken that the share price is equally likely to be anywhere within the range. That is, it has been hypothesized that the divergence prices are uniformly distributed. The uniform distribution is perhaps no more than an approximation to the distribution that can be derived from an *a priori* model of the share price generating process, but it is useful and perhaps suitable in this application. This study uses the uniform distribution for comparison purposes. It divides the sample data into two periods and tests the divergence prices for uniformity in each period. Thus the uniform distribution is used as a standard against which the observed divergence prices can be compared.

THE STUDY

In order to perform the distributional test of the impact of stock options on the underlying common stocks outlined above, it was necessary to select a sample of companies with both common stocks and listed options trading between 1978-1981. The companies in the sample were selected from the list of

highest and lowest volatility issues published in the December 24, 1981, issues of *Daily Graphs: Stock Option Guide.* Volatility is measured over the most recent 26 week period and indicates in part which stocks have the highest betas (high volatility) and may indicate which stocks provide the greatest yields (low volatility). The sample was composed of only high and low volatility issues since these two extremes represent many of the factors, other than stock options, that might also affect stock price.

Among the issues denoted as high volatility, several were excluded from the sample since either an acquisition or a proxy battle had accounted for their volatility as measured over previous 26 weeks. It was judged that the issues' behavior might, as a result, not be uniform over the entire four year period. For the most part, oil company stocks were excluded from the high volatility group.

Thirty out of the original forty issues remained in the high volatility group after excluding takeover issues. From the list of low volatility issues, a group of 30 issues were then randomly selected to match the corresponding high volatility group.

Finally, companies had to be excluded from the sample whenever data on both stock and option prices could not be obtained for the entire sample period. This occurred when options were not available for a particular company until sometime after January 1, 1978. Twenty-eight companies were excluded for this reason. Of these twenty-eight companies, twenty-two had been classified in the high volatility group while only six had been in the low volatility group. This reflects the fact that since the SEC began to relax its ban on additional option trading, the option exchanges have been adding options in more volatile issues. Investors/speculators naturally prefer to acquire options on issues that they judge may produce spectacular price leaps, such as is possible with more volatile issues. Although the sample was now more heavily weighted toward low volatility issues, with eight high volatility issues being compared with twenty-four low volatility issues, it was decided to proceed with the study, nonetheless. The alternative approach of shortening the sample period to allow for more high volatility issues was viewed as less preferable.

Four years of data were selected for analysis, 1978-1981. Within this four year span, stocks rose 26 times and fell 22 times on expiration day, hence the market's impact on stock options would not be biased to the plus or minus side. A longer time span limits the likelihood of calculating the average divergence price for a company during a period when stock prices are flat. During a period when stock prices fluctuated little, divergence price would tend to be constant, giving a biased estimate of the true long-run divergence price.

The entire four years period, 1978-1981, was divided into two separate periods. These periods were established to correspond with the period when option trading was limited to calls only and to the period when option trading included both puts and calls. The choice of a breakpoint was difficult because put trading was phased in, with the prohibition against increased put activity relaxed slowly. The time periods set were 1978 through the third quarter of 1980, and the fourth quarter of 1980 through all of 1981. These two time periods are termed calls-only and puts-and-calls respectively. Thus, the months in the last five quarters of the four-year observation period were analyzed separately from the months in the first eleven quarters. The reason is that since puts were not widely available prior to the fourth quarter of 1980, their unavailability may have had a significant impact on divergence prices. Table 1 lists the thirty-two companies included in the study, their volatility category, and the average divergence price for the two time periods under investigation.

TABLE 1

SAMPLE COMPANIES: AVERAGE DIVERGENCE PRICES FOR BOTH TIME PERIODS AND VOLATILITY

Company	Average Divergence Price		Volatility
	First 11 Qrts.	Last 5 Qrts.	
IBM	1.54	8.80	Low
3M	3.73	4.00	Low
Storage Technology	1.36	.80	High
Upjohn	-3.45	5.20	Low
American Home	1.27	-2.40	Low
First Charter Financial	9.45	.20	High
Continental Telephone	-.36	-17.60	Low
Goodyear	2.00	-2.00	Low
Lilly	-.55	-1.60	Low
Proctor & Gamble	-2.27	-8.00	Low
Union Carbide	.36	-5.60	Low
Duke Power	-16.09	-3.60	Low
Caterpiller	-1.91	8.00	Low
Consolidated Edison	-5.82	1.60	Low
National Semiconductor	-2.36	.20	High
American Hospital Supply	2.82	.40	High
Zenith	-.82	.80	High
Heublin	.27	-8.60	Low
Reynolds Metals	2.27	1.40	Low
American Electric Power	1.64	14.20	Low
Baxter	-1.36	1.60	Low
CBS	5.0	1.40	Low
Commonwealth Edison	-5.45	7.60	Low
Coke	-1.27	2.60	Low
General Foods	-3.64	5.20	Low
R. J. Reynolds	2.73	-7.00	Low
Southern	9.73	1.80	Low
United Airlines	5.64	-6.60	High
American Telephone	-3.27	-3.40	Low
Eastman Kodak	7.27	5.20	Low
Exxon	1.73	1.80	Low
Homestake Mining	5.27	6.40	High

HYPOTHESIS TESTING

The null hypothesis underlying this study is that optionable stocks fluctuate at option expiration time with no upward or downward bias *vis-a-vis* the nearby strike prices and that their fluctuations are not skewed. That is, the null hypothesis states that divergence prices, which equal the difference between common stock market prices and option prices, would appear to have been generated by a uniform probability distribution.

A chi-square goodness of fit test was employed in testing the null hypothesis for the two time periods. With this test, a sample distribution (the data observ-

ed on the thirty-two companies within each time period) was compared with a theoretical probability distribution. The theoretical distribution with which to compare the divergence price data was the uniform distribution.

The design of a general chi-square goodness of fit test is illustrated in Table 2 using the outline of the study described above and hypothetical sample data.

TABLE 2

SAMPLE CHI-SQUARE TEST

Category	Theoretical Probability	Theoretical Frequency	Sample Frequency
-20 and 20	.025	8.8	13
-19	.025	8.8	9
-18	.025	8.8	7
-17	.025	8.8	5
.	.	.	
.	.	.	
.	.	.	
17	.025	8.8	10
18	.025	8.8	6
19	.025	8.8	13
	1.0	352	352

Categories refer to the possible values obtainable in the study — observed divergence prices for each company. Theoretical probability indicates the probability that any one observation would fall into a category and, in the case of Table 2, is calculated using the uniform probability distribution. It should be noted that the sum of theoretical probabilities is unity. Theoretical frequency tells the number of observations that should be found in any category given the size of the sample. In this case, with 352 observations (32 companies × 11 quarters of observation), each category would be expected to contain approximately 8.8 observations, assuming independence of divergence prices across time and companies, if the observations were, in fact, uniformly distributed. Finally, the sample frequency column incidates the number of observations actually found in each category.

The statistic, χ^2,

$$\chi^2 = \sum_{i=1}^{n} \frac{(f_{oi} - f_{ei})^2}{f_{ei}} \qquad (2)$$

is distributed as chi-square with $n-1$ degrees of freedom, where n equals the number of categories and where f_o is the sample frequency for the ith category and f_e is equal to the theoretical frequency of the ith category as in Table 2. Once χ^2 is calculated, it is compared with the chi-square value at some significance level with a chi-square distribution with the appropriate degrees of freedom. If the calculated value exceeds the chi-square value, the null hypothesis is rejected. That is, if the sample frequency, f_o, is so different from the theoretical frequency, f_e, that the calculated statistic χ^2 becomes large, then the hypothesis that the sample was generated by a specific probability distribution is rejected.

The χ^2 statistic calculated from the data presented in Appendix 1 equals 96.93. The chi-square value with 39 (40-1) degrees of freedom at the .005 probability level equals approximatley 66.8. Thus, the null hypothesis is rejected. The conclusion is that divergence prices on stocks with tradable options during the eleven quarters from 1977 through the third quarter of 1980 were not generated by a uniform probability distribution.

Since the population distribution from which the sample data were randomly selected was not uniform, the Pearson's Coefficient of Skewness, $S = 3(\bar{x}-Md)/s$ [11, pp. 65-66], was calculated in order to obtain information regarding the shape of the sample distribution with respect to symmetry. The obtained value of S for this sample was -0.39. This value indicates that the distribution is negatively skewed; thus the majority of the observed divergence prices were positive in value. This result suggests that before the trading of puts commenced, divergence prices tended to be slightly greater than zero on average. This finding may reflect the fact that no arbitrage was occurring with expiring in-the-money pits.

Data for the last five quarters of the four-year observation period are presented in Appendix 2. As with the sample distribution obtained for the first eleven quarters, a chi-square goodness of fit test was conducted to test the null hypothesis that this sample distribution was taken at random from a uniform distribution. Because there were fewer observations ($n = 160$), categories were combined as shown in Appendix 2 to meet the requirements of the chi-square test concerning the magnitude of the theoretical frequencies. The obtained χ^2 statistic with 19 degrees of freedom was 14.25. Since the critical χ^2 value with 19 d.f. at the .05 probability level is 30.1, the null hypothesis *cannot* be rejected. The test results, then, support the notion that the distribution of observed divergence prices in the last five quarters of the observation period was uniform in shape. In other words, once both the put and call options were available for trading, divergence prices (and equity prices by inference) behaved without a bias.

CONCLUSIONS AND FUTURE RESEARCH

This study examined the prices of optionable stocks on the day of expiration of the available options. During the two time periods examined, 1977 until the third quarter of 1980 and 1980 fourth quarter until the end of 1981, markedly different results were found. The major institutional difference between the time periods

was that during the first period only call options were available because of an SEC regulation designed to minimize the potential distortions from the introduction of formal option trading. It should be pointed out, however, that a few listed puts began trading during the latter part of the first period, but volume was low.

During the first time period divergence prices, calculated to equal the difference between the closing price of the underlying stock and the nearest option strike price, did not conform to a uniform distribution, suggesting the existence of a relationship between the equities and options market. In the final five quarters of the 20 quarter observation data set, both put and call options were traded. Using the same statistical tests used in the first time period, the hypothesis that divergence prices behaved as if they had been generated by a uniform probability distribution could not be rejected. That is, divergence prices were no more likely to be zero on the day options expired than they were to be at any other price. Thus, during the second period, equities prices *were not* systematically closer to strike prices than one would expect, given change. That is, the equities markets were behaving as if no option series were expiring.

These results are different from previous research. Previous studies found some evidence of interactive influence between options markets and equities markets. This study found interactive influence for the earlier calls-only period but not for the later period when both puts and calls were traded on options exchanges. There are several possible explanations for this result. The one tentatively advanced is that the rise of put trading helped offset some induced sales of the underlying shares with induced purchases. These induced purchases relieved some of the selling pressure that specialists may have experienced as in-the-money call options approached expiration.

Further research might examine whether some threshold level of put trading was sufficient to restore symmetry and uniformity to the divergence price distribution.

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APPENDIX 1

OBSERVED DIVERGENCE PRICES (IN NUMBER OF EIGHTHS) FOR FIRST 11 QUARTERS OF 4-YEAR OBSERVATION PERIOD, 1978-1981

Category	Frequency	Category	Frequency
-19	9	0	14
-18	7	1	13
-17	5	2	18
-16	12	3	12
-15	8	4	8
-14	13	5	6
-13	9	6	5
-12	8	7	5
-11	4	8	8
-10	5	9	17
-9	9	10	6
-9	12	11	10
-7	7	12	14
-6	7	13	6
-5	4	14	6
-4	3	15	3
-3	10	16	10
-2	8	17	10
-1	9	18	6
		19	13
		*20/-20	13

*Categories 20/-20 were combined since both represented divergent price + = Trend Prior was positive, - = Trend Prior was negative.

APPENDIX 2

OBSERVED DIVERGENCE PRICES (IN NUMBER OF EIGHTHS) FOR LAST 5 QUARTERS OF 4-YEAR OBSERVATION PERIOD, 1978-1981

Category	Frequency	Combined Frequency	Category	Frequency	Combined Frequency
-19] -18	5] 2	7	-1] 0	5] 4	9
-17] -16	4] 5	9	1] 2	5] 7	12
-15] -14	6] 4	10	3] 4	4] 6	10
-13] -12	4] 4	8	5] 6	2] 2	4
-11] -10	1] 6	7	7] 8	4] 5	9
-9] -8	2] 5	7	9] 10	6] 2	8
-7] -6	1] 1	2	11] 12	5] 3	8
-5] -4	4] 4	8	13] 14	4] 2	6
-3] -2	3] 6	9	15] 16	6] 7	13
			17] 18	5] 2	7
			19] 20/-20	4] 3	7