Option Pricing Asymmetry

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Introduction

Option pricing is one of the most researched areas of finance. Several different option pricing models have been developed, each with its own strengths and weaknesses. One characteristic of these models is that call options and put options are treated as opposites by the pricing model. While such a result might be intuitively appealing, there is no a priori reason to believe that market participants price these contracts in an identical but opposite manner. Option prices reflect the behavior of the market participants, and if there is a significant difference between the behavior of the buyers/sellers of call options and the buyers/sellers of put options, then any option pricing model will need to reflect this difference in the pricing of the different contracts.

Literature Review

The Black-Scholes [1973] option pricing model provided a basis for a better understanding of the pricing of options and contingent claims securities. When applied to stock options, the model is able to explain much about how option prices are set, but there have been numerous studies that have found discrepancies between actual and predicted prices. Many researchers have attempted to explain these anomalies by changing certain characteristics of the model, like the interest rate specification process, and other researchers have focused on market factors like dividend payments to the underlying stock (for example, Black [1975], Black and Scholes [1973], Geske and Roll [1984], Gultekin, Rogalski, and Tinic [1982], MacBeth and Merville [1989], and Rubinstein [1985]). It should be noted that all of these researchers restricted their data to call options. Even the review of various option pricing models conducted by Bakshi, Cao, and Chen [1997] used only call option data.

All of this research does have a common, though seldom expressed, characteristic. In all these models the pricing of the call option and the pricing of the put option are seen to be identical, though in opposite directions. The profit and loss diagrams for calls and puts are mirror images at maturity, so it is apparently assumed that while the option is active the same pricing mechanism is at work. This assumption is further supported by the acceptance of the put/call parity theory. Even though tests of the put/call parity theory show anomalies (Brenner and Galai [1986], Frankfurter and Leung [1991], Klemkosky and Resnick [1979], Stoll [1969]), it is accepted as true, and this acceptance results in the assumed "equal-but-opposite" nature of call and put option prices.

While all this work is indeed impressive and indicative of a similarity between the pricing of calls and puts, it has not yet been proven that the pricing models for these two different contracts are the same. The lack of testing of option pricing models using data from put options provides no support for the assumption of symmetry. Theoretical constructs notwithstanding, it is possible that call and put options are priced differently in their relevant markets.

Data and Methodology

One of the difficulties in comparing call and put options is identifying comparable data points. Existing option pricing theory implies that there are several factors involved in setting the price of the contract such as time to maturity and the volatility of the underlying stock, and it can be hard to find data points that can be compared directly without having to make adjustments for specific contractual differences. There is, however, one situation that permits the direct comparison of the prices for call and put options. If the stock price closes at a strike price for an option, the call and put option prices should be equal if the pricing of the contracts is symmetrical.

The data used to examine option pricing symmetry covers the period 1995-2000. The stocks selected for the study were those stocks that had been elements of the Dow Jones Industrial Average for the entire six year period. Stocks that entered or left the DJIA during the period were not included, and stocks that changed identity through mergers or acquisitions were similarly excluded. The daily closing prices of each stock were obtained. On those dates on which the stock closed at an option strike price, the closing price of the call and put options with strike prices at the stock closing price were collected whenever there was a matching put/call pair. For example, if stock XYZ closed at 50 and there were both a call and put option with a strike price of 50 for a given maturity, the two option closing prices would comprise one observation. Since it is possible to have different maturity dates with the same strike price, it was possible to get more than one observation on each date. There were 807 option pair observations during this period. A list of the companies included in this study and the number of option price pairs for each of the stocks is shown in Exhibit 1.

EXHIBIT 1

FIRM	NUMBER OF OBSERVATIONS (CALL-PUT PAIRS)
Alcoa Aluminum	18
AT&T	51
American Express	53
Boeing	26
Caterpillar	29
Coca Cola	52
Disney	51
Du Pont	21
Eastman Kodak	21
General Electric	77
General Motors	53
IBM	79
International Paper	15
McDonald’s	45
Merck	79
MMM	19
JP Morgan	30
Philip Morris	55
Procter & Gamble	27
United Technologies	6

When the stock price closes at the strike price of an option, the only difference between the call and put option contracts of the same maturity is that one is a call and one is a put. For example, if stock XYZ closes at 50 and there are call and put option contracts available for this stock at a strike price of 50, the parameters in the pricing models for the XYZ options with the same maturity would be identical. Both contracts would have the same relevant volatility, time to maturity, and implied cost of capital. In a perfect market with symmetric pricing, all option combinations with matching maturities would have identical prices. In a less than perfect market with symmetric pricing, there could be differences in the call and put prices, but the differences should be randomly distributed, and there should be a similar number of occasions when the call price exceeded the put price as when the put price exceeded the call price. The less efficient the market, the more price mismatches, but in a market with symmetric prices the distribution would be "balanced".

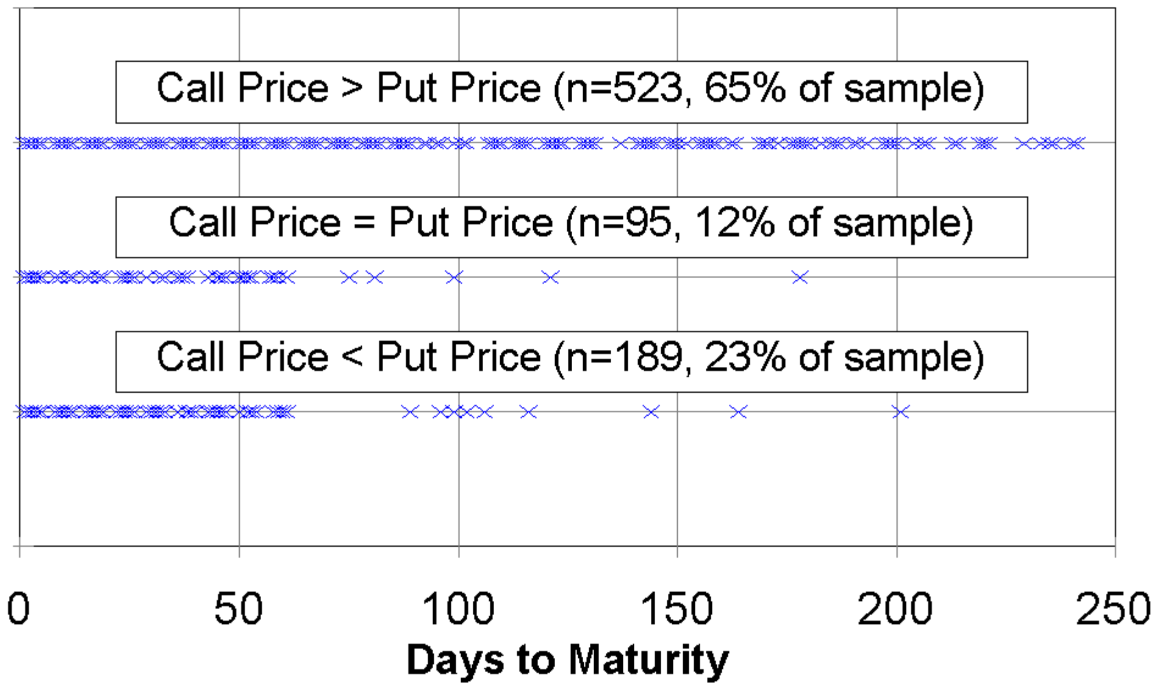
The comparison of the prices of the call and put options in each observed price pair provide evidence of the symmetry or asymmetry of the put option and call option pricing processes. If the pricing processes are really symmetric, the prices of the put and call options will be the same, though some noise could occur due to market inefficiencies.

Results

The difference between the price of the call option and the price of the put option was calculated for each observation. Exhibit 2 shows the distribution of the mispricing in the (call-put) spread. In 65% of the observations, the call price exceeded the put price while the put price exceeded the call price only 23% of the time. Exhibit 2 also shows that there are more instances of call options costing more than put options when the time to maturity of the option contract is longer. Not only is the pricing between call and put options asymmetric, the asymmetry appears to be related to time.

EXHIBIT 2

(CALL-PUT) SPREAD



In order to examine the apparent time factor shown in Exhibit 2, the difference between the price of the call and put options was calculated for each pair of observations. This (call-put) spread is graphed against time and shown in Exhibit 3. Since this exhibit includes all observations it is possible that a single stock could be responsible for a specific "section" of the mispriced observations. Exhibit 1 shows that for several of the stocks there were only a few observations. In these cases there is not enough data available for meaningful analysis. But there were several stocks with more than 50 observations, and three stocks had over 70 observations. The (call-put) spread for General Electric (Exhibit 4), IBM (Exhibit 5), and Merck (Exhibit 6) show that the time factor in the spread is indeed present in the individual stocks.

It is also possible that the time factor could have been isolated to specific time periods. Exhibits 7 through 12 examine each year of the study (1995-2000), and once again the time factor is present in all cases. The time dependent nature of the (call-put) spread mispricing is indeed a pervasive characteristic of the option market. The trend lines that appear in Exhibits 3 through 12 were calculated using simple linear regression. Exhibit 13 presents the R^2 for the regression, slope of the line, and the t-statistic for coefficient of the slope. These statistics indicate that there is similarity across all the regressions, but there appears to be significant differences between some of the individual stock series, for example, IBM and Disney. The slope of the IBM regression line is more than twice that of Disney indicating that there are stock specific factors present.

The most obvious stock specific factor is the price of the stock. During this period, observations for the IBM (call-put) pairs had strike prices ranging from 90-170. The Disney (call-put) pairs had strike prices ranging from 25-110. In order to adjust for the discrepancy in the strike price, each call and put price was divided by the strike price of the option, and the analysis was repeated. Exhibits 14 through 23 show the relative (call-put) spread for the entire sample, the specified stocks, and each year of the study. Exhibit 24 summarizes the relevant regression statistics. In 11 of the 16 cases the R^2 of the regression and the t-statistic for the slope of the line improved indicating that relative option pricing was better than absolute option pricing.

Examination of the regression coefficients reveals yet another aspect of the difference between absolute and relative values of the (call-put) spread. If the slopes of the regression lines were all identical, it would mean that the time effect had been captured regardless of how the data was partitioned, by stock or by year. The standard deviation for the absolute (call-put) spread slopes is .003527, and the standard deviation for the relative (call-put) spread slopes is .000041. If the two highest values and the two lowest values are removed from each set, the standard deviation for the absolute (call-put) spread slopes becomes .001399, and the standard deviation for the relative (call-put) spread slopes becomes .000035.

Removing the extreme values tightened the distribution of both sets of regression slopes, but the standard deviation for the absolute values decreased by about 60% while the standard deviation relative spread decreased by only about 15%. This indicates that the use of relative (call-put) prices results in more consistent data as evidenced by the stability of the different regression lines through various subsets of the data.

Based on the relative (call-put) prices, it appears that the spread between the price of call and put options increases by about $.0001 per day for each dollar of strike price. For options with a maturity of 100 days and a strike price of 50, the difference between the price of the call option and the price of the put option would be about $.50. This difference in pricing cannot be attributed to cost of capital or volatility or cost of capital since all such aspects of the contracts are identical. This indicates that there are different pricing models for call options and put options, and that these models are not simple mirror images.

Summary

The markets for call options and put options may be similar, but they are not identical. The pricing models for calls and puts are not mirror images. This lack of symmetry between call and put pricing implies that hypothesized relationships like put/call parity may be inaccurate and that models based on these hypothesized relationships will need to be revisited. One aspect of the difference appears to be that call and put options do not value time in the same way. In addition to any cost of capital assumed by the underlying pricing model, there is an additional time factor that causes the spread between call and put option prices to increase with time. No mechanism is suggested for this difference, but it is there. This is an area for future research.

References

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Stoll, H., “The Relationship Between Put and Call Option Prices”, *The Journal of Finance*, Volume 24 (December 1969), pp. 801-824.

EXHIBIT 2

(CALL-PUT) SPREAD

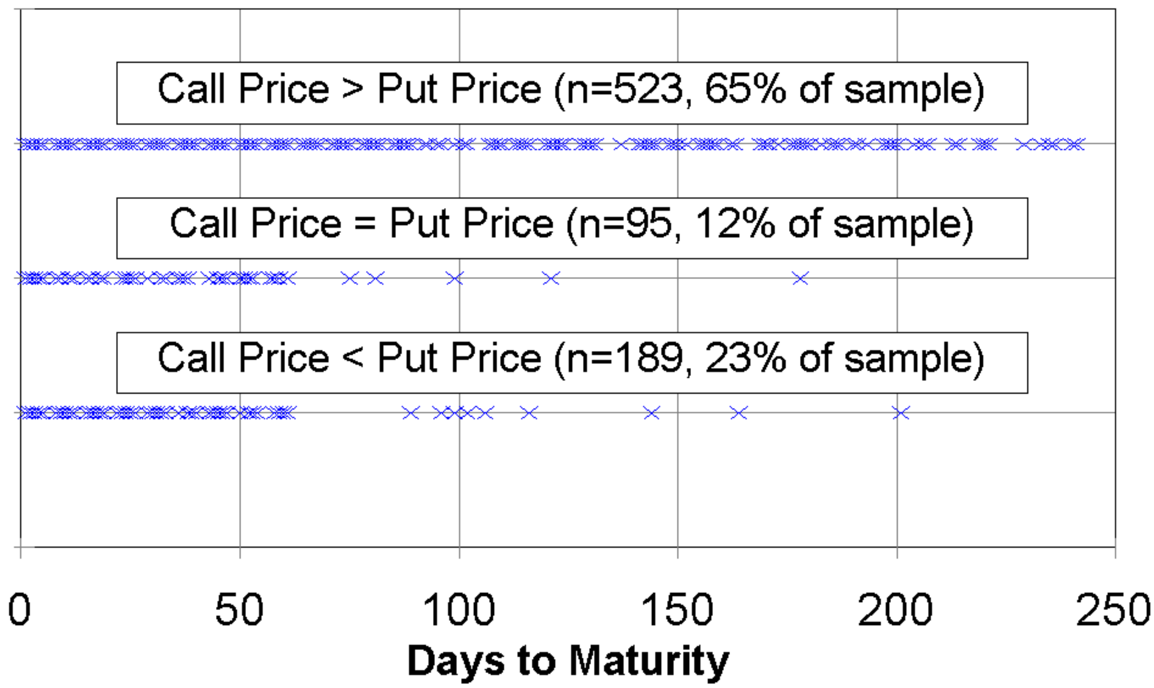

EXHIBIT 3

ALL OBSERVATIONS
(CALL-PUT) SPREAD

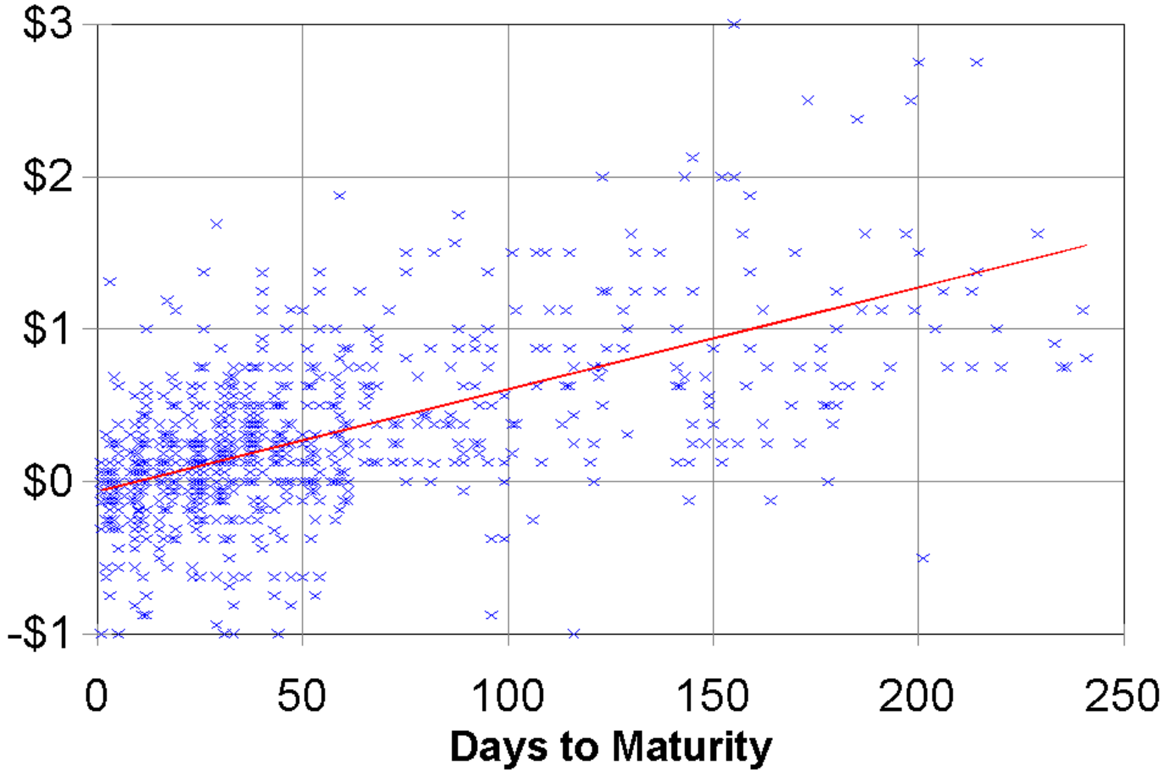

EXHIBIT 4

GENERAL ELECTRIC
(CALL-PUT) SPREAD

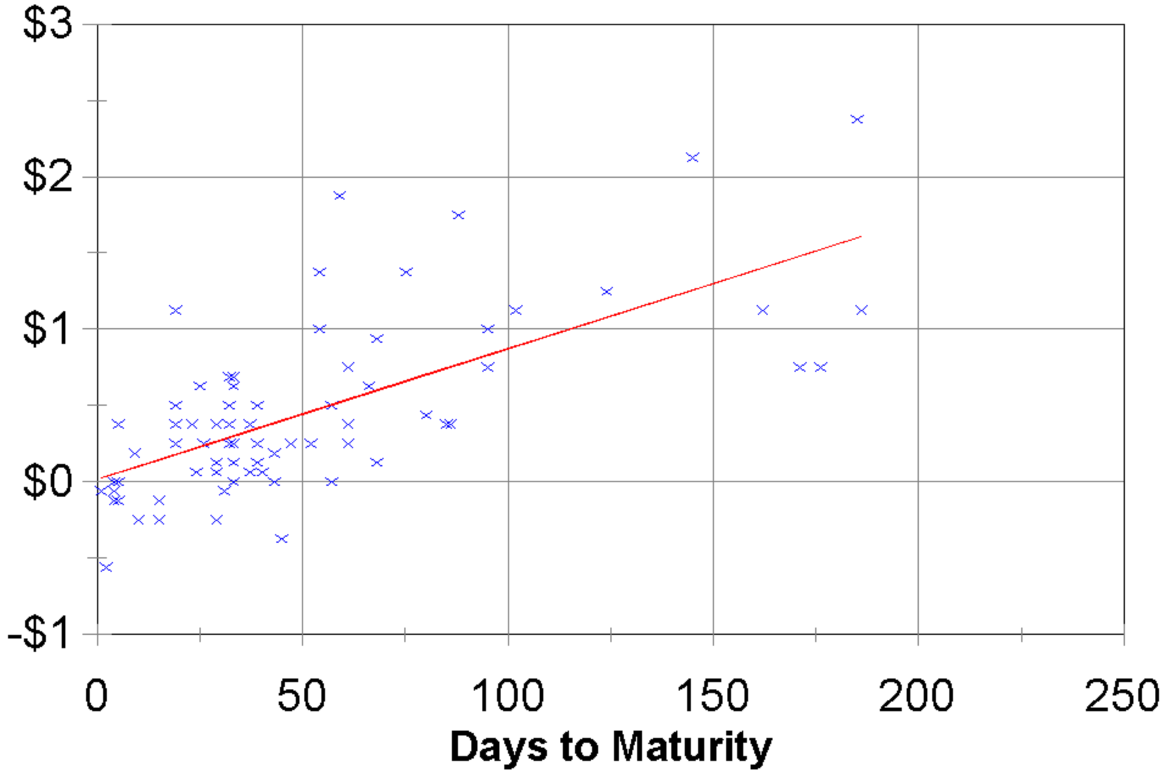

EXHIBIT 5

IBM
(CALL-PUT) SPREAD

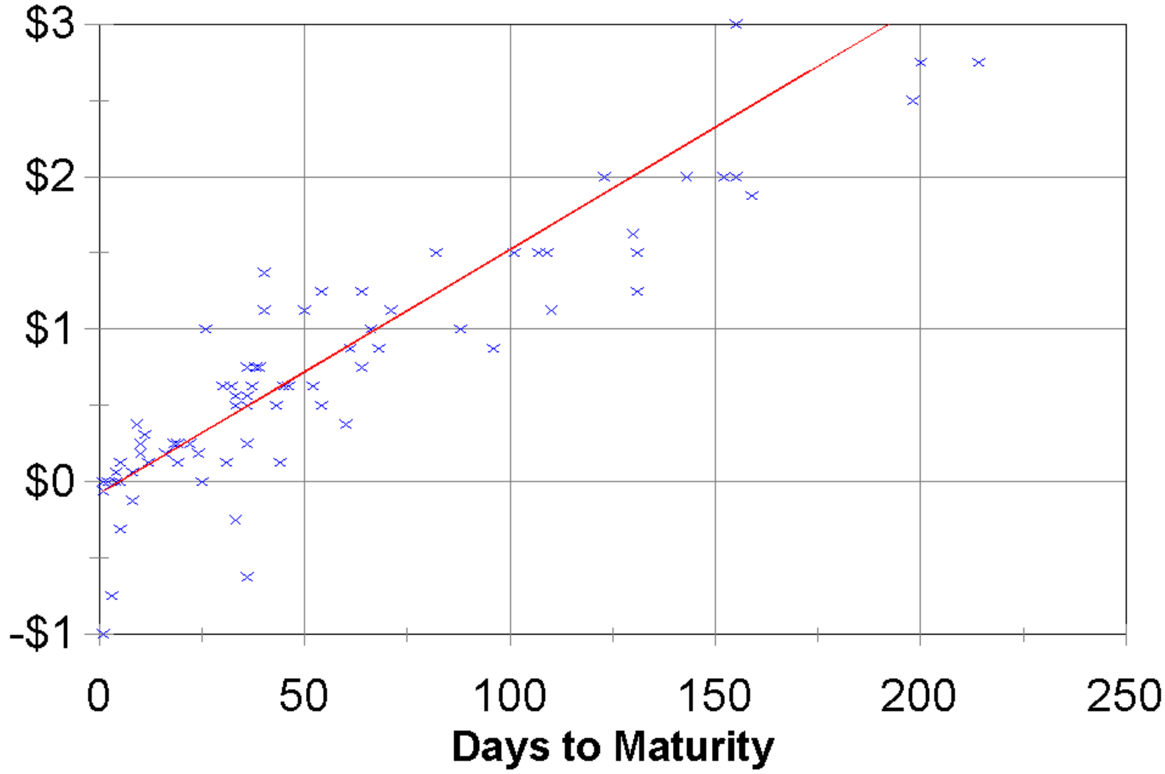

EXHIBIT 6

MERCK
(CALL-PUT) SPREAD

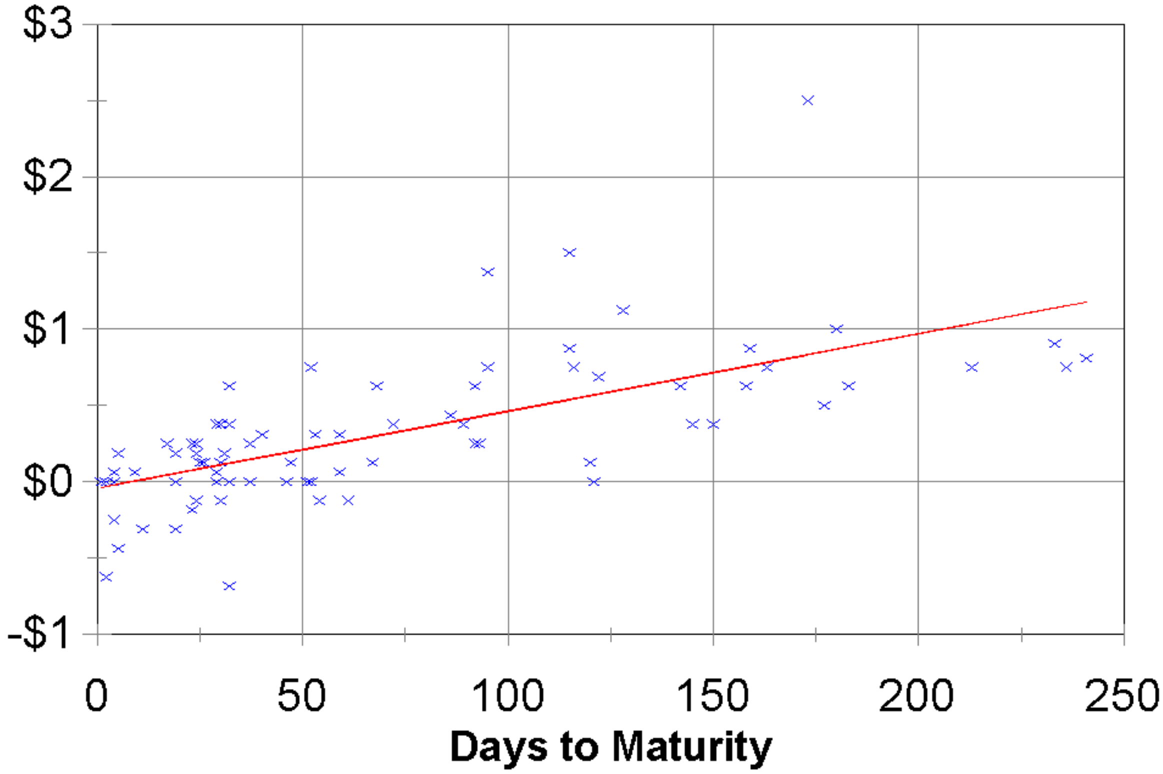

EXHIBIT 7

1995 OBSERVATIONS
(CALL-PUT) SPREAD

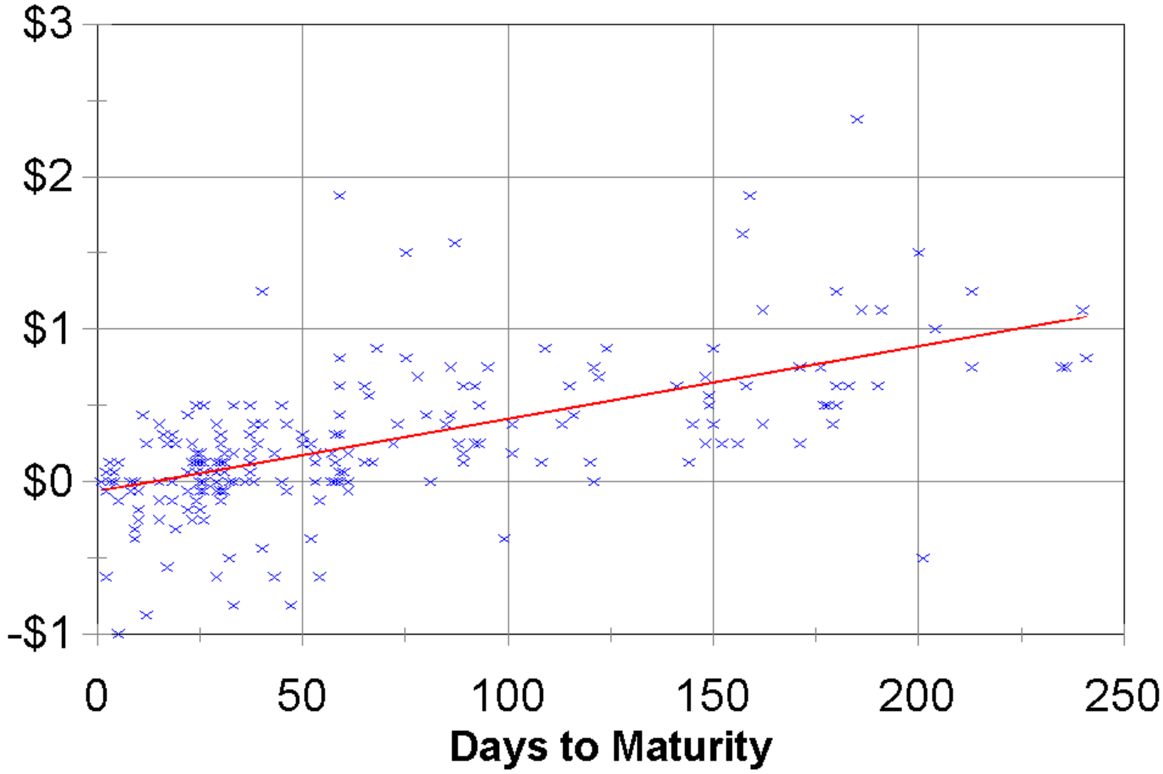

EXHIBIT 8

1996 OBSERVATIONS
(CALL-PUT) SPREAD

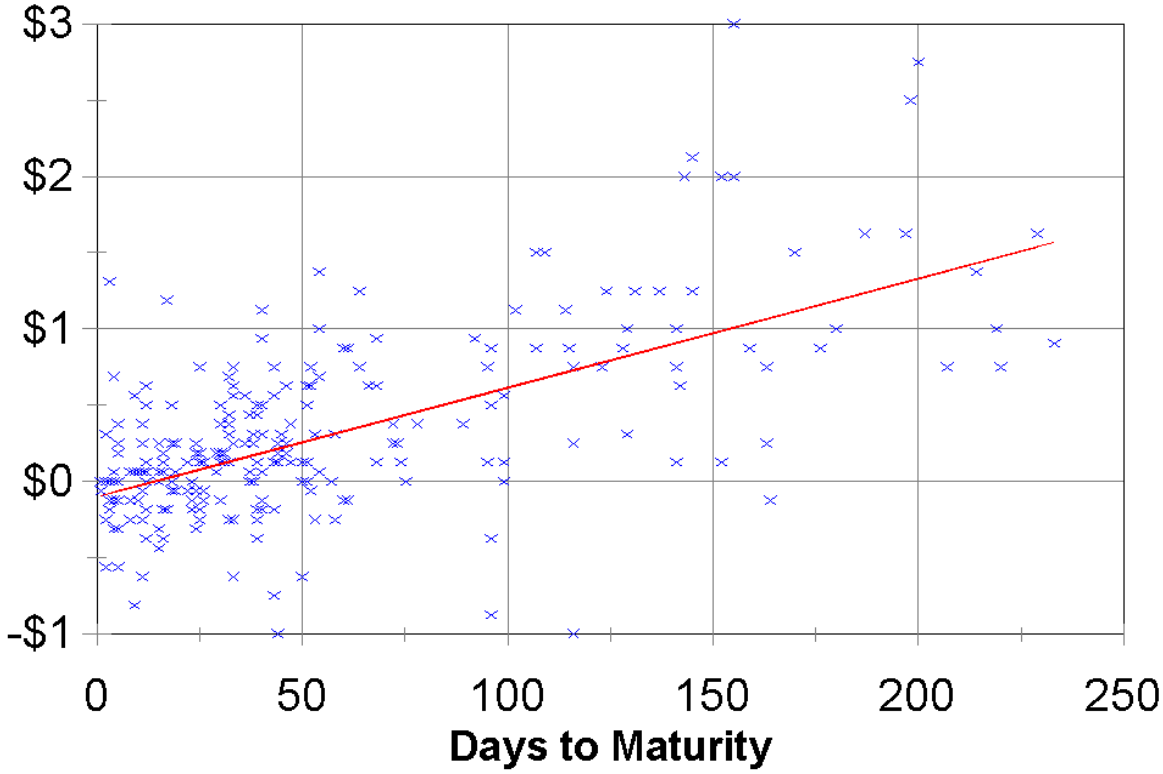

EXHIBIT 9

1997 OBSERVATIONS
(CALL-PUT) SPREAD

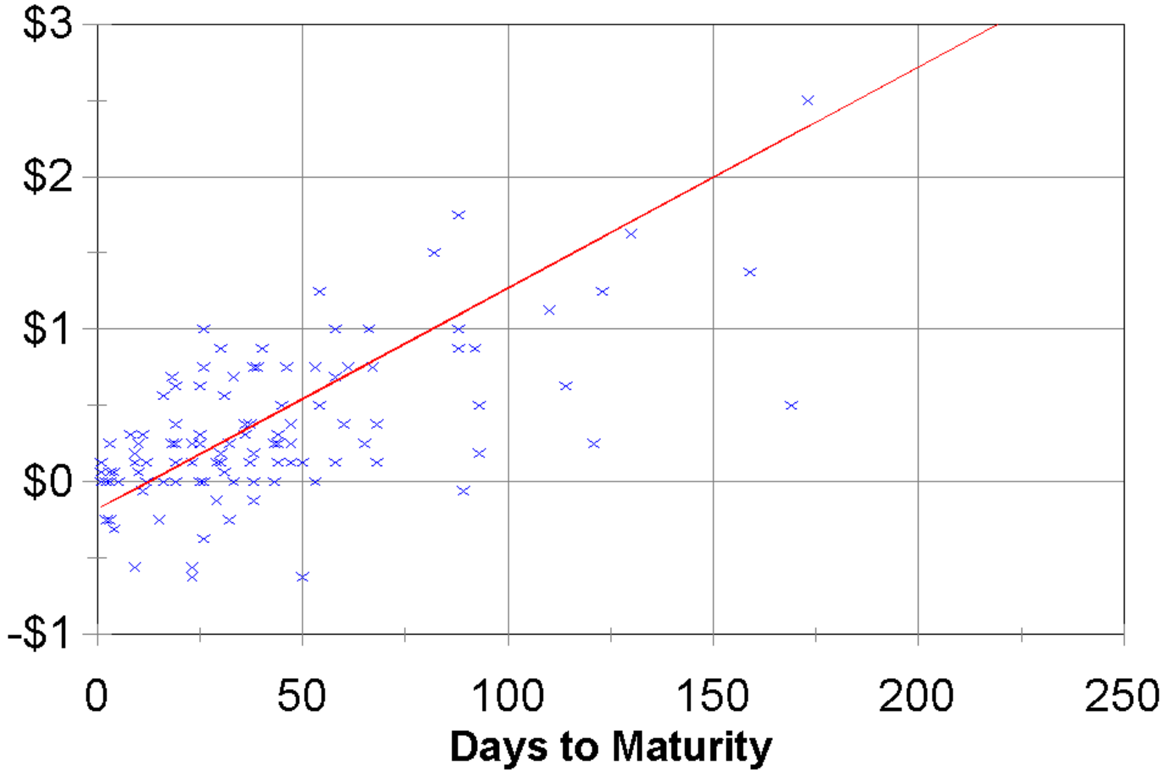

EXHIBIT 10

1998 OBSERVATIONS
(CALL-PUT) SPREAD

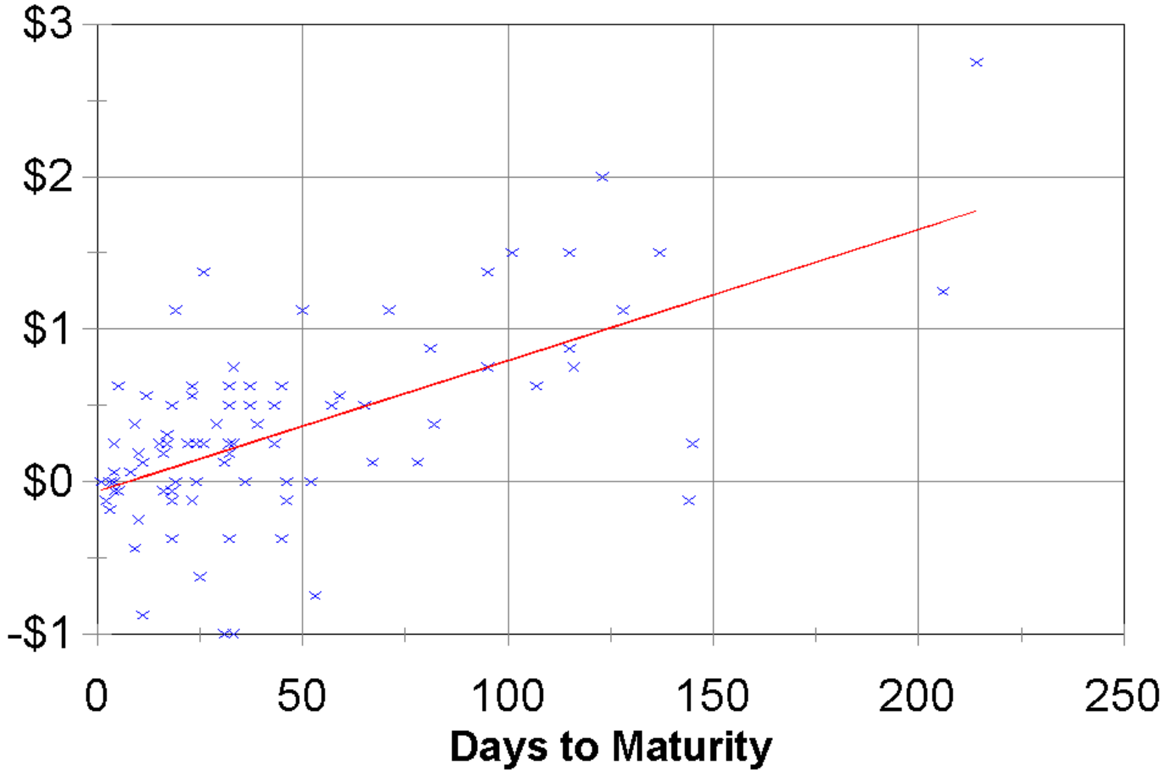

EXHIBIT 11

1999 OBSERVATIONS
(CALL-PUT) SPREAD

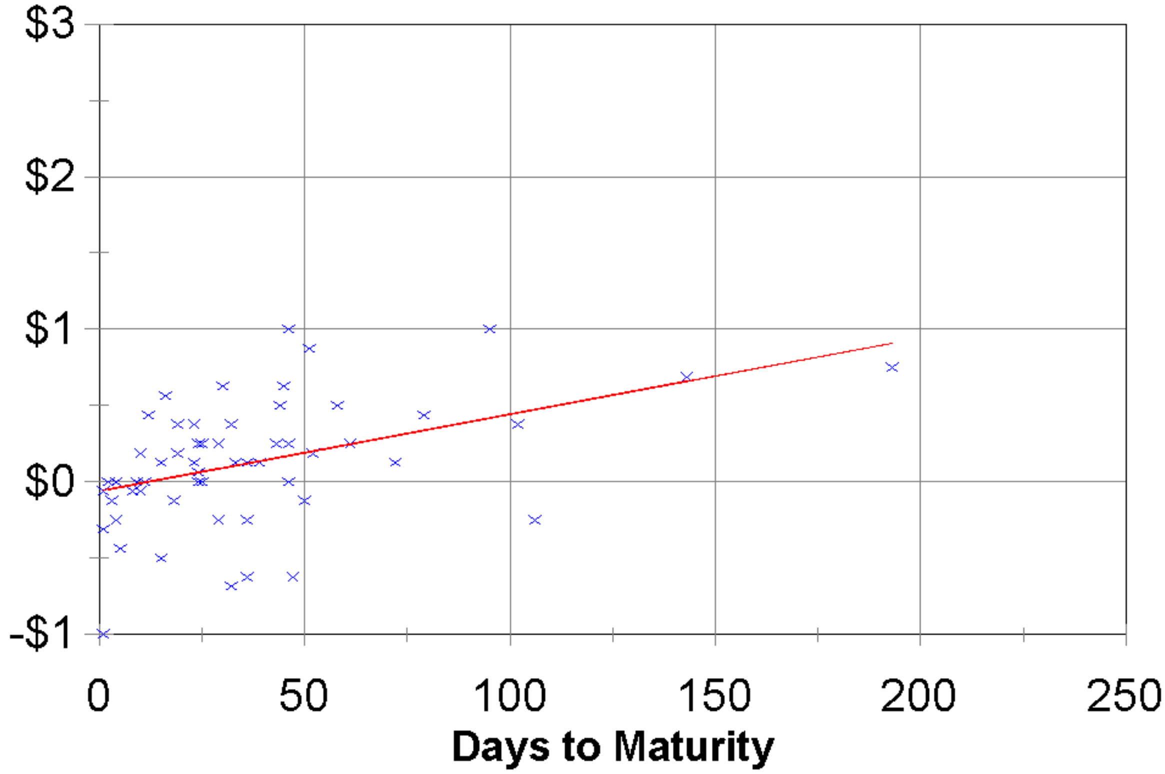

EXHIBIT 12

2000 OBSERVATIONS
(CALL-PUT) SPREAD

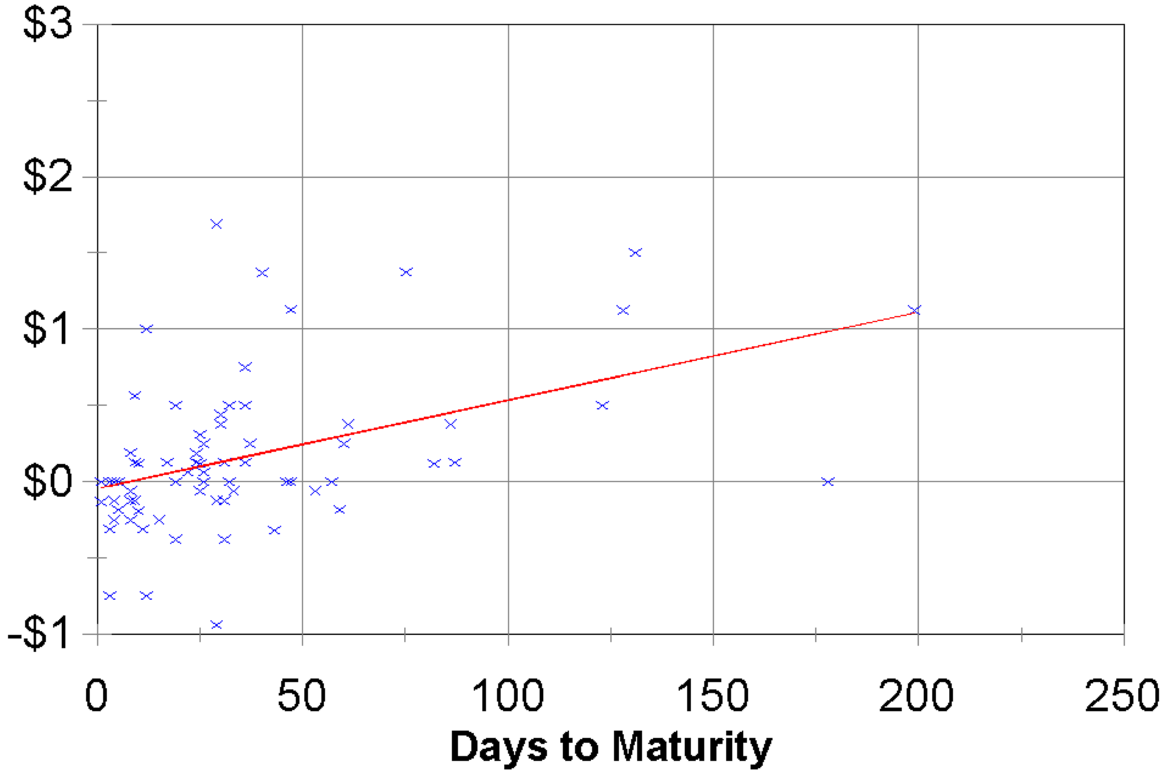

EXHIBIT 13

FIRM	R^2 OF REGRESSION	SLOPE OF REGRESSION LINE (ABSOLUTE (CALL-PUT) SPREAD)	T-STATISTIC FOR SLOPE
All Observations	0.3106	0.006691	19.04
AT&T	0.5003	0.004201	7.00
American Express	0.2918	0.004479	4.58
Coca Cola	0.5167	0.007403	7.31
Disney	0.7554	0.006858	12.30
General Electric	0.4695	0.008581	8.15
General Motors	0.6087	0.005080	8.91
IBM	0.7119	0.016028	13.79
Merck	0.4479	0.005053	7.90
Philip Morris	0.0375	0.002133	1.44
1995	0.3568	0.004764	10.82
1996	0.3560	0.007152	11.85
1997	0.5077	0.014515	10.89
1998	0.3582	0.008602	6.97
1999	0.1980	0.005029	3.78
2000	0.4537	0.005794	4.15

EXHIBIT 14

ALL OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

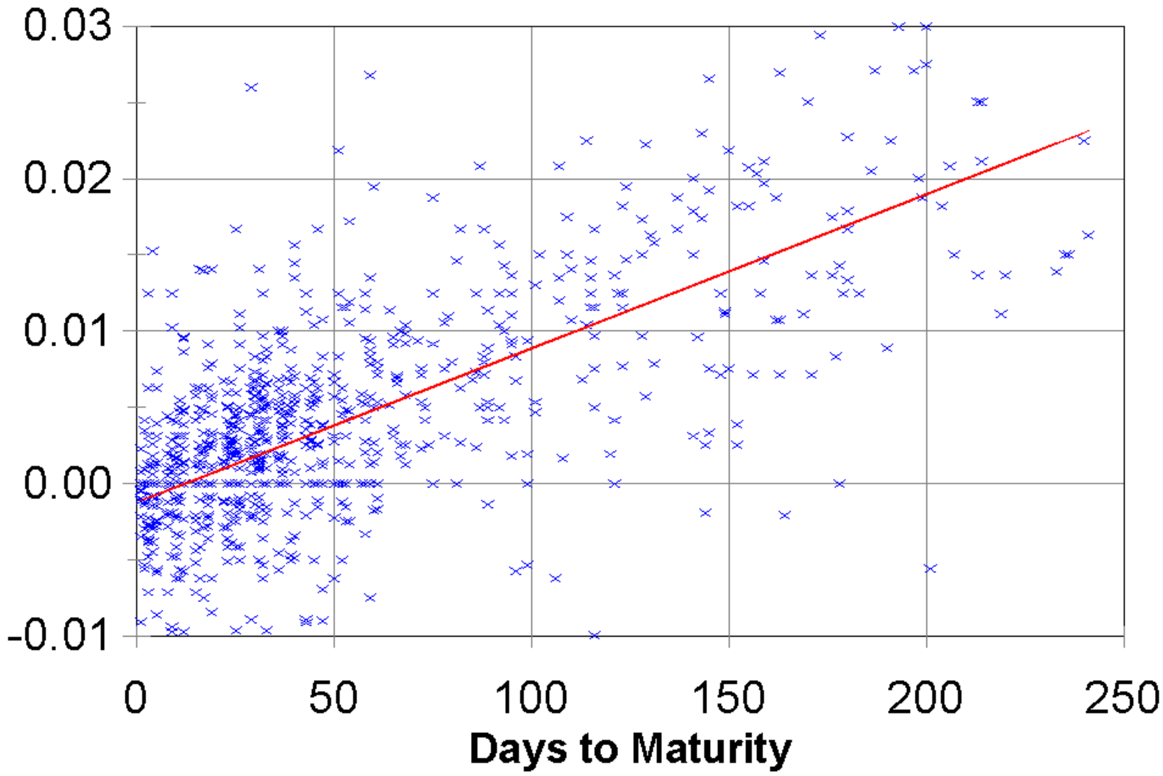

EXHIBIT 15

GENERAL ELECTRIC
RELATIVE (CALL-PUT) SPREAD

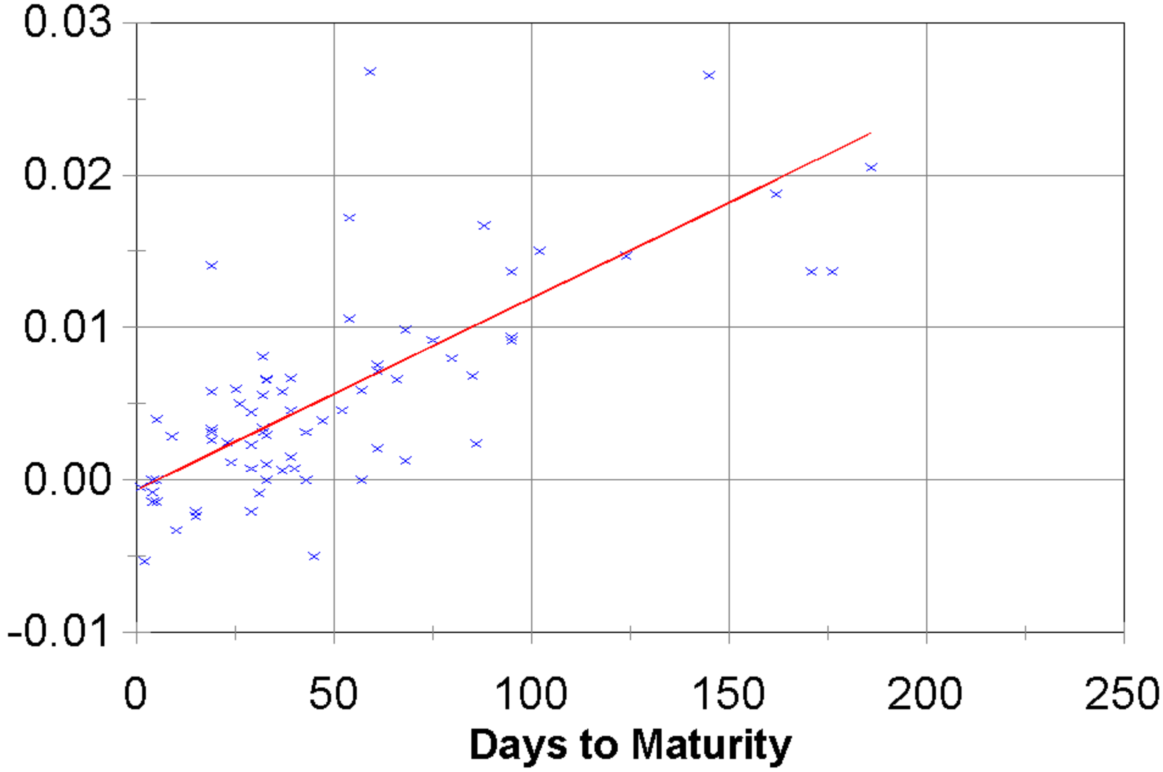

EXHIBIT 16

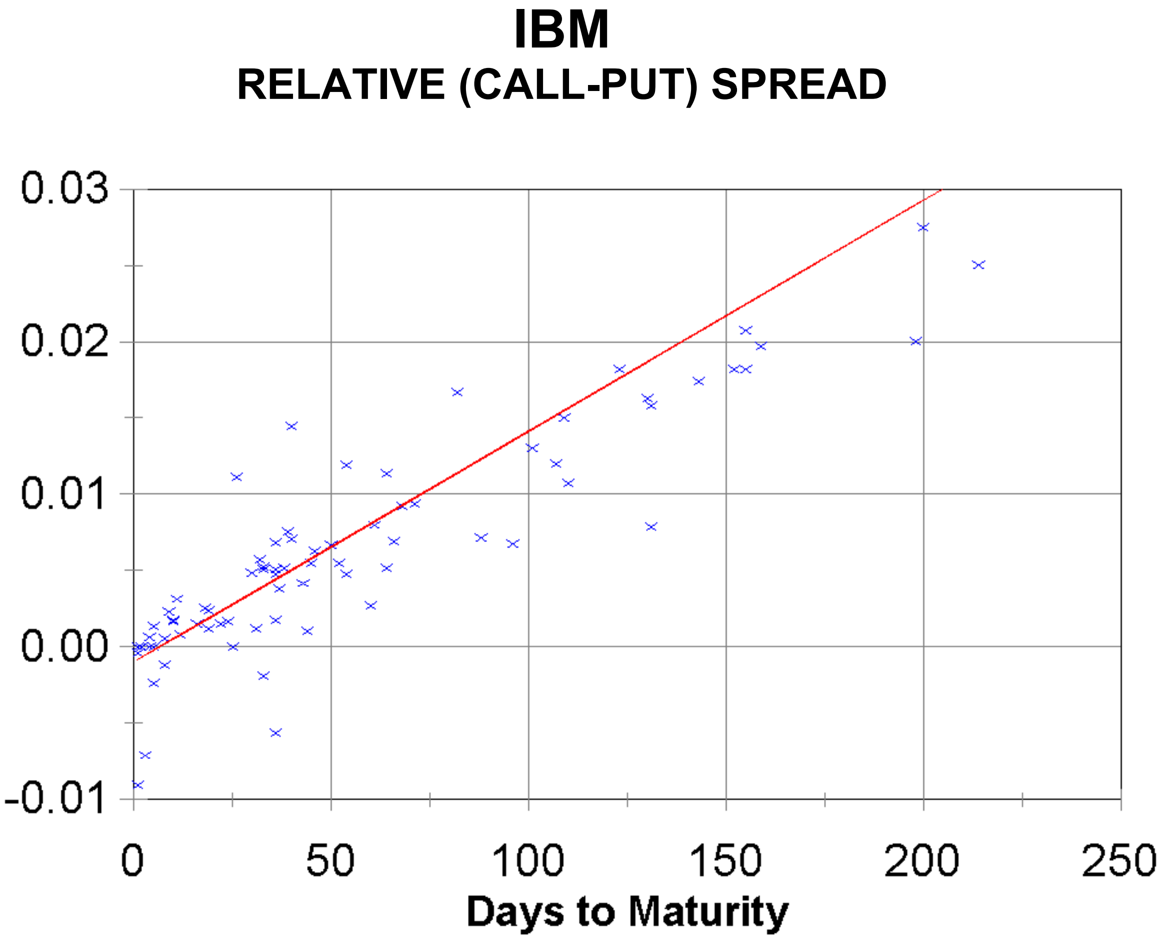
IBM
RELATIVE (CALL-PUT) SPREAD
0.03
0.02
0.01
0.00
-0.01
0
50
100
150
200
250
Days to Maturity

EXHIBIT 17

MERCK
RELATIVE (CALL-PUT) SPREAD

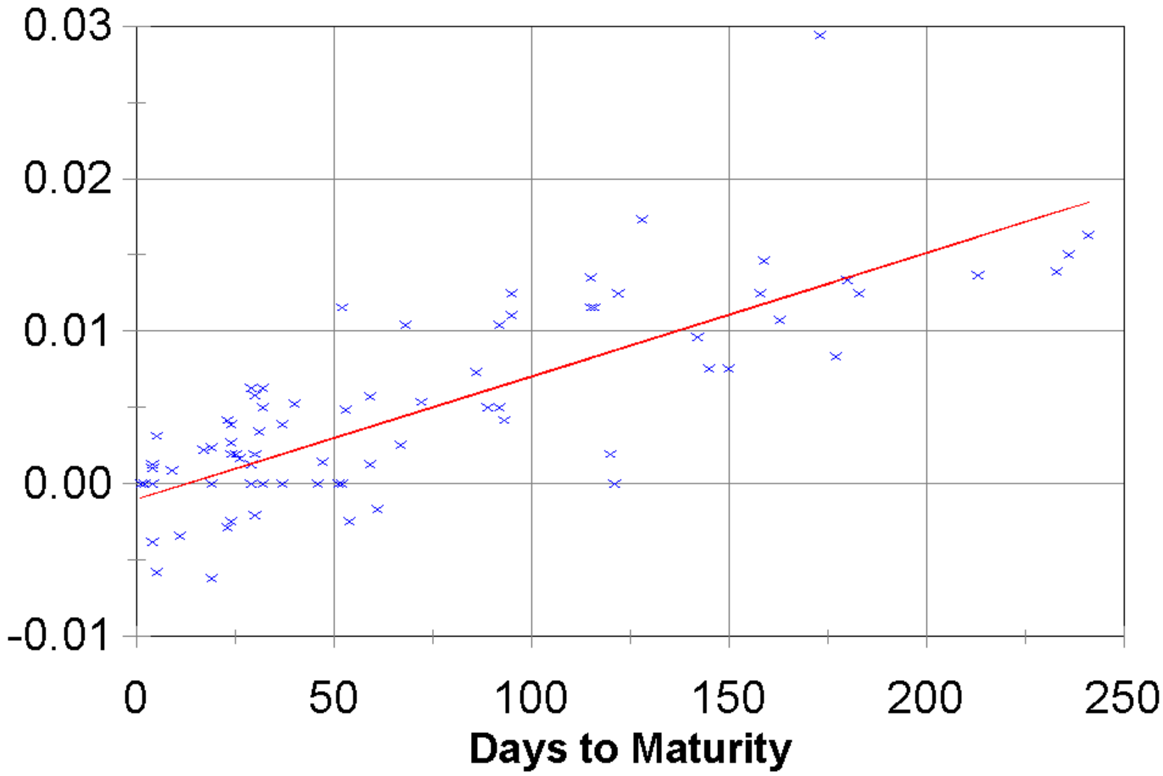

EXHIBIT 18

1995 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

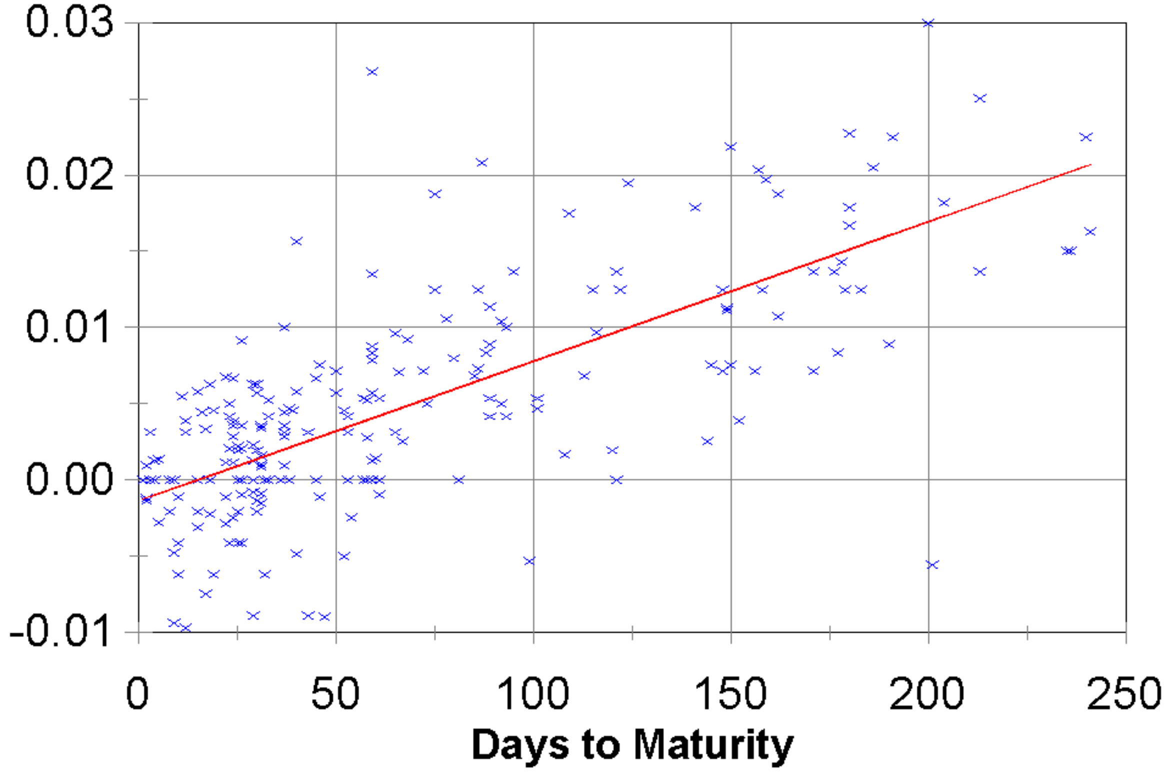

EXHIBIT 19

1996 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

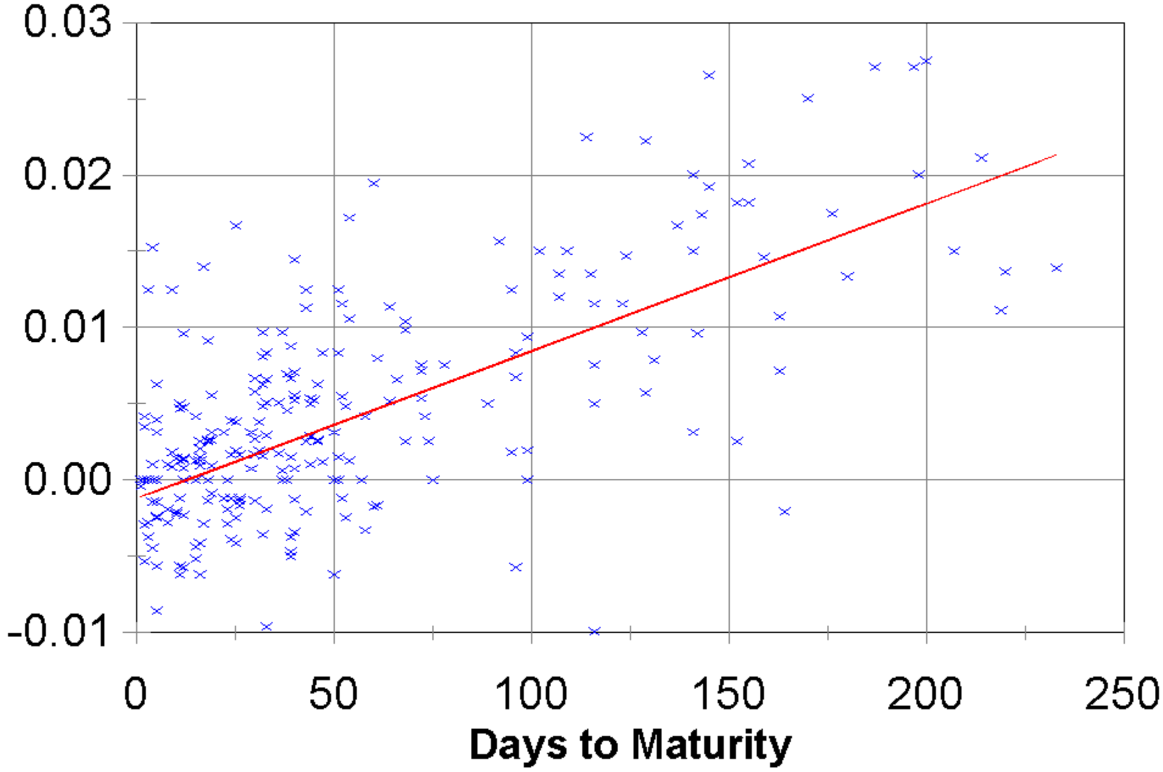

EXHIBIT 20

1997 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

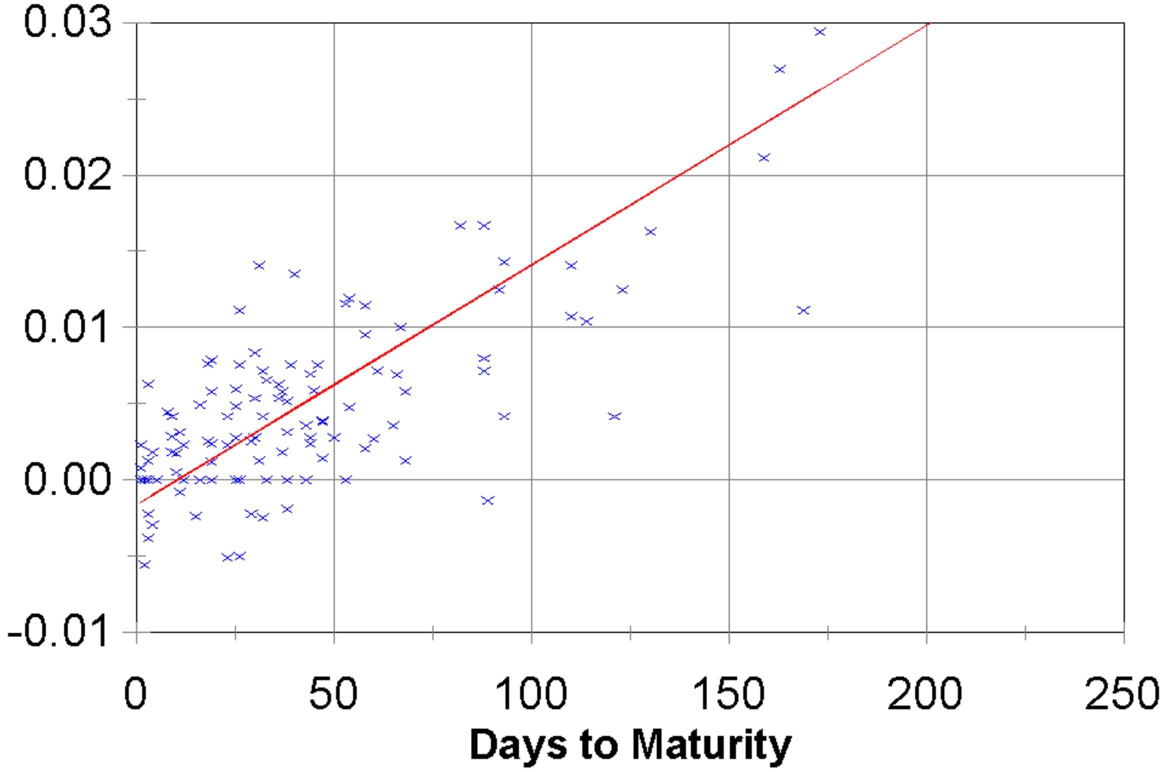

EXHIBIT 21

1998 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

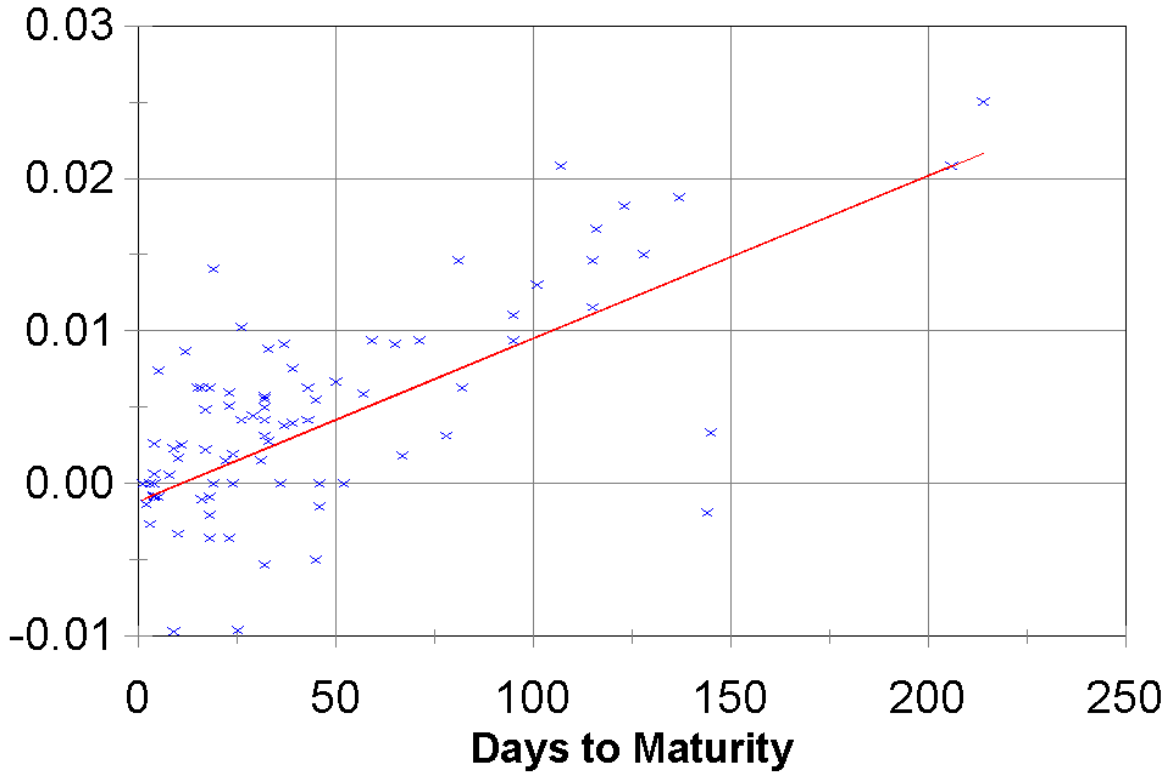

EXHIBIT 22

1999 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

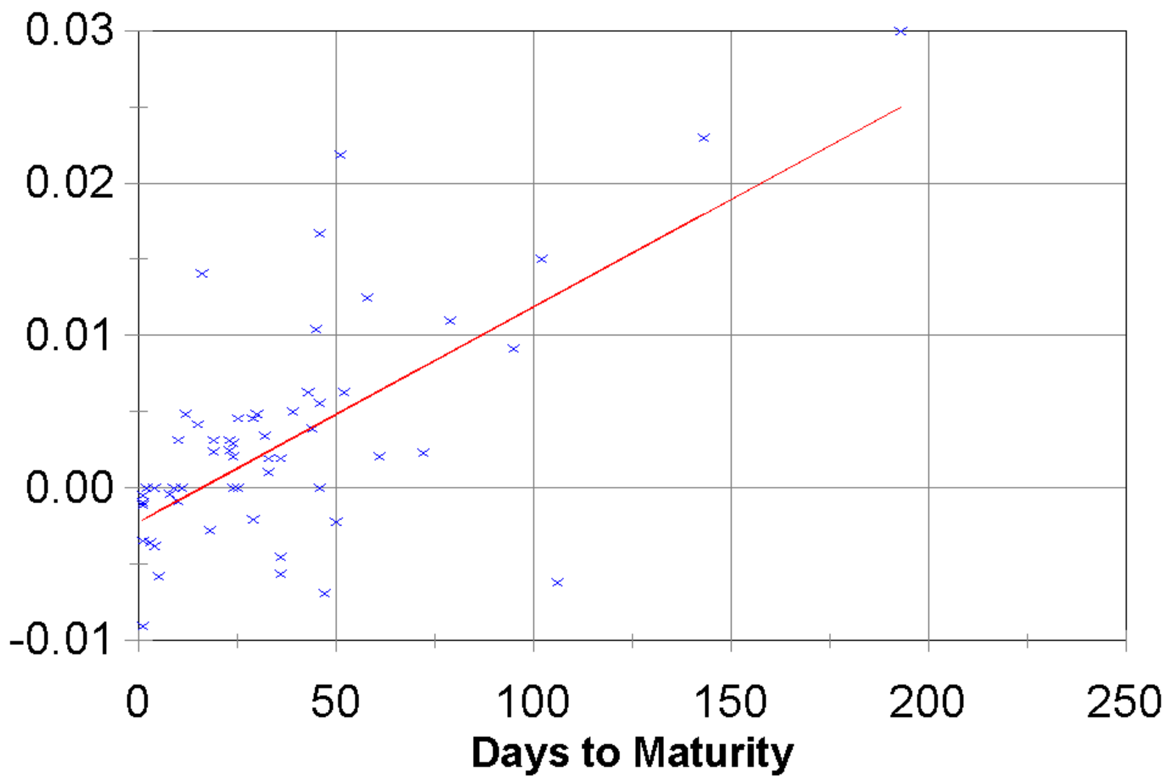

EXHIBIT 23

2000 OBSERVATIONS
RELATIVE (CALL-PUT) SPREAD

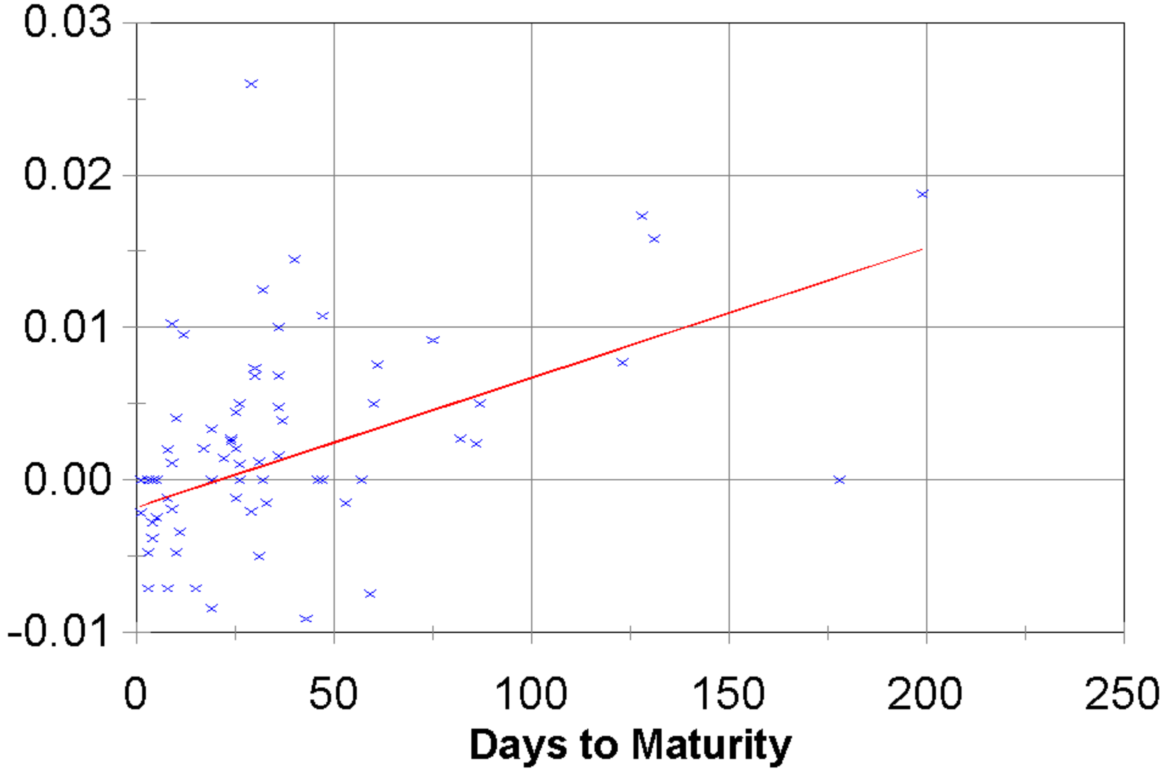

EXHIBIT 24

FIRM	R^2 OF REGRESSION	SLOPE OF REGRESSION LINE (RELATIVE (CALL-PUT) SPREAD)	T-STATISTIC FOR SLOPE
All Observations	0.3944	0.000101	22.90
AT&T	0.4914	0.000077	6.88
American Express	0.4417	0.000103	6.35
Coca Cola	0.5746	0.000114	8.22
Disney	0.8611	0.000136	17.43
General Electric	0.5881	0.000126	10.35
General Motors	0.6470	0.000106	9.67
IBM	0.6319	0.000151	11.50
Merck	0.5893	0.000081	10.51
Philip Morris	0.0291	0.000026	1.26
1995	0.4940	0.000092	14.35
1996	0.3899	0.000097	12.74
1997	0.5048	0.000157	10.83
1998	0.3781	0.000107	7.27
1999	0.4119	0.000141	6.37
2000	0.1459	0.000085	3.46