Spider Options and the S&P 500 Index Options Market

GUNTHER CAPELLE-BLANCARD§
and
MO CHAUDHURY¶

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ABSTRACT

Using daily closing options data for the January 01, 2004 to June 30, 2005 period, we examine if the listing of Spider options on January 10, 2005 had any major impact on the quoted bid-ask spread, volume and implied volatility pattern of the S&P 500 Index options. Based on regression-based measures proposed in this paper, we find the call spread and volume to shrink, and the put spread and volume to rise, leading to a minor net volume decline in total. Consequently, index put transaction cost rises for the investors and the market makers enjoy a boost in revenue while the CBOE's fee revenue perhaps suffers a little. Considering spread and volume effects, the liquidity implication is uncertain. Pricing of the S&P 500 Index options is not affected as the implied volatility pattern remains largely in tact.

Keywords: S&P 500 Index Options, Spider Options, ETF, Volatility Smile.

JEL Classification: G13.

Correspondence to: Mo Chaudhury, Desautels Faculty of Management, McGill University, 1001 Sherbrooke St W, Montreal, QC, Canada H3A 1G5, Tel: (514) 398-5927, Fax: (514) 398-3876, Email: mo.chaudhury@mcgill.ca.

§ EconomiX-Université Paris X *Nanterre* & Université Paris 1 *Panthéon-Sorbonne*. 106-112 Bd de l'Hôpital 75647 Cedex 13 Paris, France, Tel: 33-1-44078271, Fax: 33-1-44078270, Email: gunther.capelle-blancard@univ-paris1.fr.

¶ Deasuatels Faculty of Management, McGill University, 1001 Sherbrooke Street West, Montreal, QC, Canada H3A 1G5, Tel: (514) 398-5927, Fax: (514) 398-3876, Email: mo.chaudhury@mcgill.ca.

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SINCE THEIR INCEPTION at the Chicago Board Options Exchange (CBOE) in 1983, the celebrated S&P 500 Index options have commanded global leadership in index option trading.[1] However, January 10, 2005, possibly marked a new era of trading in derivatives linked to the popular S&P 500 Index. On this day, several US exchanges introduced options on the S&P 500 Depository Receipt, commonly known as Spider. This widely traded exchange traded fund (ETF) itself is listed under the symbol SPY at the American Exchange and represents a tradable security version of the S&P 500 Index.[2] Spiders are intended to track the performance of the S&P 500 Index and their market price is approximately one-tenth of the S&P 500 Index level.

The purpose of this paper is to empirically examine if trading in Spider options have had any impact on the S&P 500 Index (SPX) Options market. This paper contributes to the literature by providing empirical evidence on the effect of competition in the market for trading index option products and on the related issue of whether exclusive licensing arrangements in such markets are beneficial. The results are methodologically cleaner as well since the same market is examined before and after a clearly identified event, and the asymmetric information component of transaction cost is negligible for options on the market portfolio.

Competition in the market for options trading can take place in multiple ways such as more market makers on the same exchange, cross-listing of the same options contract on several exchanges, nationally integrated market system, alternative trading mechanisms (open outcry, electronic and hybrid), competition for option order flow from brokers, alternative exercise styles, larger or smaller contract size for the same option contract, and similar but not the same options such as index and ETF options. This paper concerns the last category of competition in the market for trading options.

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[1] According to the CBOE website, http://www.cboe.com/micro/SPDR/introduction.aspx, all-time CBOE trading volume in S&P options is more than 1.5 billion contracts, and the underlying notional value of trading in S&P options was more than $20 billion per day in 2004.

[2] The inception date for Spider is January 29, 1993. As of June 30, 2006, the Spider fund had net assets of $54.53 billion. The comparable figures for some large ETFs are $19.28 billion (NASDAQ 100 Trust, QQQQ, NASDAQ), $16.68 billion (iShares S&P 500 Index, IVV, AMEX), $5.73 billion (Diamonds Trust, DIA, AMEX), $5.65 billion (Vanguard Total Stock Market VIPER, VTI, AMEX), and $2.57 billion (iShares Russell 1000 Index, IWB, AMEX).

In a frictionless complete market setup, options are redundant securities with no pricing or microstructure implications for the underlying assets, other derivatives or assets. Given the real world departures from the ideal setup, researchers have long been interested in examining if and how the availability of options affect the underlying asset market. Results are mixed regarding the effect of options trading on the prices, risks, volume, bid-ask spread and other microstructure effects in the underlying asset market.[3] Previously, De Fontnouvelle et al (2003), Mayhew (2002), Battalio, Jennings and Hatch (2002), Wang (1999), George and Longstaff (1993), and Neal (1987) studied the micro-structure effects of cross-listing of equity options across exchanges. This paper adds to this literature by examining the effect of competition between the index (S&P 500 or SPX) option market and the associated ETF (Spider) option market. The importance of any micro-structure and pricing effect in the SPX option market can hardly be overemphasized as it is extensively used by institutional and retail investors for market speculation, market risk management and index (spot, futures, options, and futures options) arbitrage purposes.[4]

In a related vein, whether exclusive licensing helps or hurts the suppliers and the consumers has always been a much debated issue in empirical economics. The results of this paper shed light on this key issue in the context of options trading for the most important market portfolio in the world, namely the S&P 500. While equity options have had cross-listing for some time now,[5] options for the much followed S&P indexes are available only on the CBOE, and Spider options were not available anywhere until January 10, 2005. The natural question then arises why there were no Spider options available for nearly twelve years since the inception of Spider trading in 1993.

The introduction of the Spider options was indeed preceded by an intense controversy between McGraw-Hill, the owner of Standard and Poor's, and the CBOE on one side, and several other parties led by the International Securities Exchange (ISE), the largest options exchange, on the other side. The CBOE had exclusive licensing agreement with McGraw-Hill to list options on the S&P Indexes, and they argued that the listing of Spider options at other exchanges without first obtaining a license from McGraw-Hill will

[3] Mayhew (2000) provides an excellent survey on the effect of derivatives trading.

[4] Equivalent option products are either not available or do not have comparable liquidity for the currency, commodity, fixed income, and most stock ETFs.

[5] Mayhew (2002) provides a brief overview of the history and regulation of cross-listing of equity options.

violate intellectual property rights and hence will take away the reward for bearing the risk of financial innovation. The ISE and the opponents advocated that such exclusive listing arrangements are anti-competitive and impose higher transaction costs on users. For example, traders pay an additional exchange fee for index contracts that are exclusively listed and the bid-ask spread also appears higher for such contracts. In a letter to the SEC, David Krell, ISE Executive, pointed out that trading costs diminished when in 1999 exchanges began competing in equity options.

Ironically, by arguing that exclusive listing rewards risk of financial innovation, the CBOE and McGraw-Hill, in fact, provided support for Krell's argument that competition or multiple listing of Spider options will have the beneficial effect of lower trading costs for users. Also, the fact that CBOE itself did not introduce Spider options until 2005 indicates their worry about cannibalization in volume of the SPX options.

The listing controversy was further animated by two legal developments. In a legal suit filed by NASDAQ against Archipelago Exchange, a federal district judge in Manhattan ruled in September 2004 that Archipelago could not be prohibited from listing the NASDAQ 100 ETF, popularly known as the Cube. Obviously this emboldened the argument that licenses are not required for listing publicly traded securities or options on such securities. Separately, the Federal Justice Department launched an investigation into the long-felt absence of options on ETFs that track the S&P 500 Index. This was part of a broader investigation into possible "product allocation agreement" between the CBOE and the AMEX not to offer similar products.

Interestingly, the debate and the proceedings about exclusive listing of index related derivatives took place in the absence of a detailed empirical study in this regard. While the Cube options had multiple listing and proved to be highly successful as anticipated, the comparable NASDAQ 100 Index options did not have much success to start with.[6] Thus, drawing reliable conclusions from examining this pair would have been challenging. We hope that the results of this paper about the effect of Spider options on the SPX options will be helpful to exchanges, regulators and other practitioners in answering some outstanding claims about the effects of competition or the lack thereof (exclusive licensing or listing) on the providers and users of index option products.

Lastly, while the underlying portfolio is the same for the SPX and the Spider, there are a number of notable differences. The SPX options are cash settled European options while the Spider options are deliverable American options. The SPX options are traded exclusively on the CBOE in an open outcry system, but the Spider options are traded on multiple exchanges (including the CBOE) with varying trading mechanisms. Comparable strikes are sometimes not available across the two markets and the tick sizes are different as well. Due to these factors, instead of comparing the two markets in a matched fashion along the line of Mayhew (2002), we study the SPX option market before and after the listing of Spider options. The before-and-after methodology avoids the need for matching options and the associated errors of imperfect matching of options. Importantly, when applied to the index option market, the bid-ask spread changes are also more reflective of competition rather than components such as adverse selection. This is because any asymmetric information problem for the market portfolio is expected to be minimal.[7] Accordingly, we can expect cleaner results regarding the effect of competition alone (in the index options market) which is the focus of our study. On the other hand, our methodology may be subject to specification error of any regression relationship used. To this end, we estimate alternative nonlinear forms where applicable.

In this paper, we analyze three aspects of the S&P 500 Index options market, namely bid-ask spread, contract volume and implied volatility smile. The bid-ask spread is the source of revenue for the option market makers and it is an important component of transaction cost for the option investors. Contract volume is the most popular measure of option market activity and is the main driver of option exchange's revenue. The bid-ask spread and the contract volume are, of course, two of the most important dimensions of option market liquidity. Lastly, the implied volatility smile of the S&P 500 Index options is the most well-known stylized fact about the pricing structure of index options. It is worthwhile to examine if the availability of similar option products elsewhere affects the relative pricing pattern of the S&P 500 Index (SPX) options.

Based on the analysis of daily closing data on SPX options over January 01, 2004 to June 30, 2005, our main findings are as follows. First, the listing of Spider options

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[6] The tracking security for the Dow Jones Industrial Average (DJIA) trades under the symbol DIA at AMEX and is commonly known as the Diamond. Options for DJIA and DIA are available, but they are not as popular as the SPX, Spider and Cube options.

[7] As reported by Vijh (1990), even for equity options, the adverse selection component is surprisingly small in the option market compared to the asset market.

increased (reduced) the quoted dollar spreads for S&P 500 put (call) options. These changes are not large, but are quite pervasive. The unfavorable put spread effect here is in conflict with prior evidence (e.g., De Fontnouvelle et al (2003), Mayhew (2002), George and Longstaff (1993), and Neal (1987)). Of course, we investigate a different type of competition and the S&P 500 Index options market has some unique aspects, for example, it is the premier place for portfolio insurance. Some methodological differences may also have played a role.

Second, there is a good deal of evidence of a sizeable boost (drop off) in the S&P 500 put (call) options volume, leading to a small net decline in the total options contract volume. Considering both spread and volume effects, the liquidity benefits are not clear for the investors. Admittedly, the spread and volume effects are tempered by weakness in terms of statistical significance. However, given the predominance of put options trading in this market, the S&P 500 option market makers likely got a boost in revenue from the effective relaxation of the exclusive licensing for S&P 500 products. The CBOE's loss in exchange revenue from a net total volume decline is rather minor.

Third, the implied volatility smile of the S&P 500 options remains largely in tact. Thus, there is no evidence of asset pricing implication of additional derivatives on the market portfolio.

The rest of this paper is organized as follows. In section I, we describe the data that we use. The empirical results in section II are followed by summary and conclusions in section III.

I. Data

All data used in this study are retrieved from the OptionMetrics database of the Wharton Research Data Services (WRDS). Our main sample consists of daily closing data on S&P Index options from January 1, 2004 through June 30, 2005. As the Spider options became available on January 10, 2005, we divide the sample into two sub-samples, the pre-listing sub-sample runs from January 1, 2004 to January 9, 2005 and the post-listing sub-sample covers the rest of the sample from January 10, 2005 to June 30, 2005.

Daily options data includes the best closing bid and offer, Implied Volatility based on the closing mid-quote, the closing index level, the risk-free rate and the dividend yield on the index. In line with prior studies, we apply a number of screening criteria. First, we retrieve data for options maturing in 14 days to 365 days only. Second, the call and put observations are merged by the trading date, expiration date and strike price, and then options with the strike price more than 20 percent away from the closing index level are screened out. Third, we filter out observations where the closing best bid price is less than 25 cents for either the call option or the put option for the same strike and expiration date. Fourth, observations are excluded if either the best call bid price exceeds the closing value of the S&P 500 Index or the best closing put bid price is greater than the strike price. Lastly, options with missing implied volatility data are taken out. These are mostly deep out of the money or deep in the money options.

After the above screening measures, our final sample has 40,492 observations for the SPX call options and the same number of observations for the SPX put options. Of these, 29,032 option observations are in the pre-listing sub-sample and the remaining 11,460 option observations are in the post-listing sub-sample.

For a more detailed look, we further sub-divide the observations into five moneyness and four maturity buckets. Moneyness is defined as the ratio of the closing S&P 500 Index level (S) to the Strike Price (K) and time to maturity (T) is measured in terms of calendar days between the date of trading and the option expiration date. In line with prior research, moneyness buckets are defined as follows: deep out of the money (DOTM) call or deep in the money (DITM) put ($S/K \leq 0.925$), out of the money (OTM) call or in the money (ITM) put ($0.925 < S/K \leq 0.975$), at the money (ATM) call or at the money put ($0.975 < S/K \leq 1.025$), in the money call or out of the money put ($1.025 < S/K \leq 1.075$), and deep in the money call or deep out of the money put ($S/K \geq 1.075$). Maturity buckets are determined in the following manner: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$). Thus, we report results for a total of 20 moneyness-maturity buckets at the most detailed level.

In order to discern general trends in index options markets, the main sample of S&P 500 Index option observations are joined with pre-listing and post-listing aggregate options volume data for the S&P 100 and NASDAQ 100 options and the CBOE Volatility Indices VIX (S&P 500) and VXO (S&P 100) in some analyses. Further, we use January 01, 1996 to June 06, 2005 daily data on S&P 500 Index return, aggregate call and put option contract volume data for S&P 500, S&P 100 and NASDAQ 100, and the CBOE Volatility Index VIX, in estimating a regression equation for the S&P 500 Index options volume.

II. Results

In reporting and discussing the results, we focus on how the mean of a variable of interest has changed from the period prior to the listing of Spider options ("Before") to the period following the listing of Spider options ("After"). The change in the mean, i.e. Mean "After" less Mean "Before" is denoted by "Change" and "% Change" stands for change in mean as a percentage of the mean prior to the listing of Spider options. To evaluate the statistical significance of the change in mean, we use F-Statistic and the associated P-Value (in decimals). P-Values less than 0.05 are interpreted as statistically significant changes and P-Values less than 0.01 are taken to mean highly significant changes.

Since the Spider options were listed on January 10, 2005, the pre-listing sub-sample runs from January 01, 2004 to January 09, 2005 inclusive and the post-listing sub-sample covers the rest of the sample from January 10, 2005 to June 30, 2005 inclusive. For the sake of completeness, we also report statistics for the entire sample period, referred to as "Overall" in the Tables.

The empirical results are presented in three subsections. The liquidity results at the aggregate market level (all SPX options, all SPX call options, and all SPX put options) is presented in Subsection A, followed by the disaggregated call and put option bucket results in Subsection B. Finally, in Subsection C, we investigate if the internal structure of SPX option prices, as embodied in the Black-Scholes-Merton Implied Volatilities, has changed in any discernible manner due to the listing of Spider options.

A. Impact of Spider Options on the Liquidity of SPX Options

There are three dimensions to liquidity, namely the dollar bid-ask spread or alternatively the percentage bid-ask spread that adjusts for the dependence of the dollar bid-ask spread on the price level, quote depth and volume. Unfortunately our end of day data does not include the quote depth for the SPX options. As a result, in this study, we analyze the end of day quoted dollar (and percentage) bid-ask spreads and daily volume to evaluate the liquidity effect of Spider options listing on the SPX options.[8]

Panels A and B of Table I contain summary statistics for the quoted dollar bid-ask spread of the S&P 500 Index call and put options before and after the listing of Spider options. Based on 29,032 pre-listing and 11,460 post-listing observations for call options, the average dollar bid-ask spread seems to have increased by $0.055 or 3.36 percent (from $1.651 to $1.706) following the listing of Spider options. The dollar bid-ask spread for put options, on the other hand, dropped by $0.194 or 12.31% (from $1.578 to $1.383). On a per contract basis, this means average increase of $5.50 in the bid-ask component of trading costs for SPX call options and average decrease of $19.40 for SPX put options. The probability values for the one-way ANOVA F-Statistics are less than 0.01% indicating a very high level of statistical significance for the changes in the dollar bid-ask spreads.

The decline in the univariate or unconditional mean of the S&P 500 Index put option spreads is in line with earlier such results on equity option spreads. Mayhew (2002) finds that the quoted dollar bid-ask spread of cross-listed equity options is narrower by about $0.04 compared to matched singly-listed options. For a similar but more restricted sample, Wang (1999) reports that the quoted dollar bid-ask spread of cross-listed equity options is narrower by about 14% compared to the exclusively listed options. Examining the before and after spreads of cross-listed equity options, De Fontnouvelle et al (2003) find the quoted dollar bid-ask spread to drop by more than 50% following cross-listing. That we find the unconditional mean of the S&P 500 call spreads to widen, rather than to narrow, following the listing of Spider options raises the question whether the index option spreads behave differently than the equity option spreads. It also remains to be seen if we obtain similar results in a more controlled multivariate analysis.

Since the option premium level may affect the behavior of dollar option spreads, let us also look at the percentage bid-ask spread (=100*dollar bid-ask spread/mid-quote) results in Panels C and D of Table I, as a prelude to the controlled analysis. On average, the percentage bid-ask spread actually decreased from 7.821% to 6.198% for call options, and increased from 8.568% to 11.734% for put options, in the wake of the listing of Spider options. As can be seen in Panels A and B of Table II, the decrease in the percentage bid-ask spread of call options is due to a relatively larger (16.4%) increase in the premium level compared to the dollar bid-ask spread. Similarly, the increase in the percentage bid-ask spread of put options is caused by a relatively larger drop (44.34%) in the option premium

[8] We cannot also calculate the effective bid-ask spread since we do not have information about the closing transaction.

level. Thus, the bid-ask spreads did move in the same direction as the corresponding premium level, albeit the directions are opposite for call and put options.

One reason why the call premiums increased and the put premiums decreased in the post-listing period is that the S&P 500 Index level trended up in the post-listing period by about 0.006% per day. Panels C and D of Table II show that the divergent movement of the call and put premiums was not caused by their implied volatilities. On average, the implied volatility of SPX call options dropped by 1.876% (11.48% percentage change) in the post-listing period, from a level of 16.346% to 14.469%. For SPX put options also, the average implied volatility diminished by a similar magnitude of 1.861% (11.13% percentage change), from a level of 16.718% to 14.856%. Similar average levels and changes in the implied volatility of call and put options are of course expected due to the no arbitrage condition of European put-call parity. The drop in the implied volatility of index options is also documented, in Panels E and F of Table II, by the drop in the CBOE Volatility Indices, VIX (S&P 500) and VXO (S&P 100).

While the dollar bid-ask spreads share the direction of the premium levels, it is not clear whether the magnitude of spread movement is warranted by the premiums alone. The premium-spread relationship can be nonlinear and determinants of the bid-ask spread other than the premium level might play a role. Thus, to evaluate the effect of Spider options listing on the bid-ask spread of SPX options, we need to account for the effect of premium level and other potential determinants of the bid-ask spread.

Theoretical models of microstructure focus on either the inventory costs or the asymmetric information costs of market making as the determinants of bid-ask spread.[9] In the inventory cost models, the bid-ask spread increases with the price level and the asset price volatility, and decreases with trading volume.[10] In the asymmetric information models, the bid-ask spread is related to the degree of the adverse selection problem. Back (1993), Biais and Hillion (1994), John et al (2000), and Easley, O'Hara and Srinivas (1998) extend the asymmetric information approach to option bid-ask spreads. According to Cho and Engle (1999) and Kaul, Nimalendran and Zhang (2001), the market makers hedge

[9] Madhavan (2000) provides a review of these models.

[10] Empirical studies, e.g., Harris (1994) and Bessembinder and Kaufman (1997), also suggest relationship between option spreads and option price, volume, and volatility.

inventory and information risks in the underlying asset market, and as such the extent of hedge and the costs of hedging determine the option bid-ask spread.

In their empirical investigations of option spreads, Neal (1987), George and Longstaff (1993), and De Fontnouvelle et al (2003) use guidance from the theoretical literature in selecting predictors for the option bid-ask spreads. Using three five-day samples of near maturity at-the-money equity call options traded on the AMEX in 1985 and 1986, Neal (1987) studies the impact of increased competition in the equity options market due to cross-listing of options. He uses a cross-listing dummy variable in the regression equation to estimate the effect of competition while controlling for the effects of premium level (mid-quote) including a dummy variable for low price (less than $0.50) options, daily contract volume and underlying stock volatility measured by the option implied volatility.[11] Consistent with the equity spread literature,[12] Neal (1987) finds that equity option bid-ask spread is positively related to premium level and negatively related to contract volume, and competition due to cross-listing reduces option spreads. The evidence on the effect of price volatility is, however, mixed, as in the case of equity spreads.

In exploring the pattern of S&P 100 Index option spreads, George and Longstaff (1993) use similar variables in their cross-sectional regression equation for the quoted dollar bid-ask spreads, averaged over 15 minutes interval between 2:00 PM to 2:15 PM Central Standard Time. These variables, believed to be related to the competitive market-making costs of the CBOE index option market makers, are the premium level (midpoint of average bid and ask), the time to maturity, the average time between trades during the day (402 daily trading minutes/number of transactions), the squared Black-Scholes-Merton delta of the option, and a dummy variable representing the increase in tick size when the option premium exceeds $3.00. The time between trades is a summary measure of liquidity or demand for options that may vary across strike price and maturity classes. Lower demand increases the average time between trades and hence the risk of uncovered option positions. The squared delta is an approximation for the variance in option price

[11] The use of implied volatility is preferred since volatility measured from transaction data is spuriously positively correlated with the bid-ask spread.

[12] Please see Neal (1987) and George and Longstaff (1993) for a list of studies on bid-ask spread in the equity market.

change that influences the magnitude of variation in the value of uncovered inventory positions. The premium level proxies for the incremental costs of changing inventory, and the time to maturity represents the greater risk of early exercise assignment for near maturity options as the option writers know about the assignment the next day.

In their sample year, 1989, George and Longstaff (1993) find that the above regression model explains 68.8% and 67.5% of variations in the dollar bid-ask spread of S&P 100 Index call and put options respectively.[13] As expected, they find higher premium level, shorter maturity, higher tick size for more expensive options, and lower liquidity or demand, as measured by the time between trades, to increase the bid-ask spread. However, they find it puzzling that a higher delta reduces the option spread.

Applying a panel regression methodology to OPRA (Option Price Reporting Authority) data, De Fontnouvelle et al (2003) examine effective spreads of equity options of 28 stocks that attracted additional options listing on several exchanges in 1999.[14] Among the control variables, they find statistically significant marginal effects of the premium level (+), the effective spread for the underlying stock (+), the option delta (+), series volume (–) and some price range dummies. They do not find option gamma and implied volatility of the stock to have any consistent or significant marginal influence on the effective spread. As De Fontnouvelle et al demean the regressors and use a multiple listing dummy, their regression Intercept measures the mean effective spread prior to multiple listing and the multiple listing dummy coefficient is intended to capture the mean multiple listing effect. They find this multiple listing effect to be negative and significant for call as well as put options. In terms of magnitude, the reduction in effective spread due to multiple listing is around 3 to 4 cents or about 30% of prior mean effective spread even after extending the post-listing period to one year after multiple listing.

Based on the above theoretical and empirical studies, we estimate the following cross-sectional regressions on a daily basis, separately for call and put options:

$$\ln(\text{Spread}_{i,t}) = \beta_0 + \beta_1 \ln(\text{Contract Volume}_{i,t}) + \beta_2 \ln(\text{Option Premium}_{i,t}) + \beta_3 \ln(\text{Option Volatility}_{i,t}) + \beta_4 \ln(\text{Option Gamma}_{i,t}) + \beta_5 \text{ Money Bucket}_{i,t} \quad (1)$$

[13] The explanatory power of the regressions in Neal (1987) ranges between 15% and 22%.
[14] Please see Tables V and VI of De Fontnouvelle et al (2003), pp.2454-2458.

The subscript i.t refers to the i-th option on day t. Quoted Dollar Spread is the closing dollar quoted bid-ask spread, Contract Volume is the number of contracts traded, Option Premium is the middle of the closing bid and ask quotes, Option Volatility is the mid-quote Black-Scholes implied volatility times the absolute value of delta (using mid-quote Black-Scholes implied volatility), Option Gamma is the Black-Scholes gamma (using mid-quote Black-Scholes implied volatility), and Money Bucket is a dummy variable indicating option moneyness with values 1 (DOTM), 2 (OTM), 3 (ATM), 4 (ITM) and 5 (DITM).

We have also tried an extended set of regressors including a dummy variable to indicate if the option premium is above or below $3.00 to control for the differential tick size, and a dummy variable to represent maturity buckets. However, due to close relationship to other regressors, they magnify instability (over time) of the signs of the coefficients without adding much explanatory power. Alternative functional forms such as linear or powers of regressors do not improve the stability or the fit either.

Equation 1 is estimated daily over the sample period of January 01, 2004 to June 30, 2005. This results in 257 and 120 estimates of each regression parameter (β) in the pre-listing and post-listing periods respectively, equaling the number of trading days. In Table III, we present the Pres-Listing (Before) and Post-Listing (After) Mean of the regression parameters (Panel A), their t-statistics (Panel B) and tw0-sided probability values in decimal (Panel C), and the Regression Degrees of Freedom and R-Square% (Panel D). To see if the change in Mean is statistically significant, we also report the two-sided probability value of a two-sample t-test with unequal observations and variances.

Our contention is that the listing of Spider options may affect the option spreads in two ways. An indirect effect may take place if the listing of Spider options changes the coefficients or the marginal effects of the included regressors on the option spread. A direct effect, on the other hand, will work through a change in the Regression Intercept or Constant, which by default includes the mean effect of omitted variables. Accordingly, we estimate two alternative predicted values of the spread for all option observations in the post-listing period:[15]

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[15] It is to be noted that, due to the nonlinearity of the regression function, the predicted spread estimator is not unbiased although the predicted log of spread is. For lognormal spreads, our spread estimator will be

$Spread_{i,t}$ (A) = exp $\{\beta_0^{Post} + \beta_1^{Post}$ ln(Contract $Volume_{i,t}$) + β_2^{Post} ln(Option $Premium_{i,t}$) + β_3^{Post} ln(Option $Volatility_{i,t}$) + β_4^{Post} ln(Option $Gamma_{i,t}$) + β_5^{Post} Money $Bucket_{i,t}\}$

$Spread_{i,t}$ (B) = exp $\{\beta_0^{Pre} + \beta_1^{Pre}$ ln(Contract $Volume_{i,t}$) + β_2^{Pre} ln(Option $Premium_{i,t}$) + β_3^{Pre} ln(Option $Volatility_{i,t}$) + β_4^{Pre} ln(Option $Gamma_{i,t}$) + β_5^{Pre} Money $Bucket_{i,t}\}$

In the above definitions of $Spread_{i,t}$ (A) and $Spread_{i,t}$ (B), the β^{Pre} parameters are the averages of the 257 daily estimates in the pre-listing period and β^{Post} parameters are the averages of the 120 daily estimates in the post-listing period. In both definitions, however, the actual daily post-listing values are used for the right hand side variables. Spreadi,t (B) is our predicted spread for the i-th option on day t of the post-listing period if the β's in the post-listing period were on average the same as the pre-listing β's. On the other hand, Spreadi,t (A) is our predicted spread for the i-th option on day t of the post-listing period using the average β's in the post-listing period. Using these two predicted values, we can now estimate the Spider Effect on the S&P 500 option spreads:

$Spread\_Diff_{i,t}$ = $Spread_{i,t}$ (A) – $Spread_{i,t}$ (B)

In other words, $Spread\_Diff_{i,t}$ is intended to capture the difference between the expected spread with (A) and without (B) the listing of Spider options. In previous studies such as De Fontnouvelle et al (2003), the focus is on the Direct Effect of events such as cross-listing on option spreads, measured by a change in the regression Intercept or the coefficient of a listing dummy; other regressors or variables are meant to control for the determinants of spreads not related to the events. In contrast, our measure additionally includes the Indirect Effect on option spreads of change in the marginal impacts of these determinants. If the marginal impacts change due to listing, the Indirect Effect cannot be ignored when the means of the regressors are not zero (or the same in case of demeaned regressors) in the pre-listing and post-listing periods. In that case, a zero expected Indirect Effect will result only by chance. Our approach to measuring the listing impact is thus a little more general than in prior studies.

It is worth mentioning the assumptions we are implicitly making in using the Spread_Diff measure: (i) our regression specification for the systematic component of the

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biased downwards. However, since we are looking at the difference of two predicted spreads, the bias issue may not be important.

option spread is adequate, (ii) the regression parameters or coefficients have a constant mean within a period (pres-listing or post-listing), and (iii) any difference in the average parameter values is due to the direct (change in Intercept) and/or indirect effect (change in coefficients of the included regressors) of the Spider options listing.

Before proceeding to the Spread_Diff results in Table IV, the regression results are presented in Table III. In line with theory and prior evidence, Panel A of Table III shows that increased volume on average reduces the spread while a higher premium level widens the spread, for both S&P 500 call and put options. According to Panels B and C, the premium effect is statistically significant on average, but the option volume effect is not. This is perhaps due to the fact that only a few option series are actively traded on a given day although the quotes are available and are updated for all series. As in George and Longstaff (1993), higher option price volatility seems to narrow down spread, but the effect is not consistent and statistically significant. One possible reason for this could be the downward sloping implied volatility smile for the S&P 500 Index options. With lower strike, the absolute value of delta for the put options decrease lowering the option price volatility measure and thus the spread. But the implied volatility tends to increase with lower strike, leading to higher option price volatility measure and wider spreads. For call options, the directions are reversed, but they are still opposing. Joined together, the opposing effects may create instability and reduce the magnitude of the net impact of option price volatility on the spread. The average negative tendency that George and Longstaff (1993) and we find says that the absolute delta effect may be a bit stronger than the implied volatility influence.

Option gamma or convexity increases risk for the market makers leading to a wider spread, but the effect lacks statistical significance in the case of put options. Interestingly, as indicated by the negative averages of the Money Bucket coefficients, deeper in the money options tend to have a lower dollar spread controlling for the other effects including that of the premium level. This effect on the dollar spread is fairly consistent across the sample and statistically significant too. Our Money Bucket dummy is positively correlated with the premium level. Since we are already controlling for the premium level, the Money bucket may be a proxy for a higher order premium effect. In this sense, the negative average coefficient for the Money Bucket variable indicates that the percentage (in a double log specification) increase in the spread slows down at higher premium levels. As the premium level represents the extent of hedging an option position in the underlying market, the negative Money Bucket effect could mean economies of scale in hedging costs. An alternative explanation lies in the adverse selection approach, where option market makers perceive the problem to be less important for in the money options. This is because informed traders deciding to trade in the options market will find the leverage of the out of the money options relatively more attractive.

Overall, the explanatory power of our regressions is quite high, averaging in excess of 80%. This indicates impressive fit given that the degrees of freedom on an average day are not that high, 107 in the pre-listing period and approximately 89 in the post-listing period.

It is clear from Panel A that the directions of the marginal relationships (sign of the parameters or coefficients) are quite stable and have not been impacted much by the listing of Spider options. Comparing the average t-statistics (Panel B) and the probability values (Panel C) before and after the listing of Spider options, the statistical significance of the variables also appear largely unaffected. Option Premium and Money Bucket are the two variables that are statistically significant at 5% both before and after the listing of Spider options, for call as well as put options.[16] The positive Option Gamma effect is on average significant for Call Options at 10% before the listing and at 5% after the listing.

In Panel A, probability value of the t-test of mean change shows that the decline in the positive effect of option premium (from +0.5359 to +0.4699) on call option spread is statistically significant at 1%. At the same time, the negative effect of Money Bucket became more negative (from –0.1857 to –0.2093) and this change is also significant at 1%. In the case of put options, the slight increase (from +0.5710 to +0.6081) of +0.0024 in the positive effect of option premium is not statistically significant. The negative Money Bucket effect gets a bit less negative (from -0.1971 to -0.1630) and this change is statistically significant at 1%.

The direct impact of Spider options listing is the change in the Regression Intercept or Constant. Panel C shows that the Intercept is not statistically significant for call options and put options in either the pre-listing or the post-listing period. However, the sample Intercept declines on average from +0.3964 to +0.3365 for call options translating to a predicted decline of 5.81% in the call dollar spread. For put options, the average decline in the Intercept is rather dramatic, from +0.7747 to +0.2951, and this decline is significant at 2% level. The severe decline in the Intercept likely reflects the actual decline of 12.31% in the put option spread.

Since we are really interested in the post-listing spread with and without the listing of Spider options, we need to examine Table IV statistics concerning the Spread_Diff which combines the Direct (change in Intercept) and the Indirect (change in marginal effect of regressors) effects. Panel A of Table IV contains some summary statistics on Spread_Diff while a more detailed cumulative frequency (%) distribution is provided in Panel B. Based on 11,459 call option and an equal number of put option daily closing quotes in our screened sample, the listing of Spider options, on average, seems to have narrowed the S&P 500 call option spread by $0.0427 ($4.27 per contract) while widening the S&P 500 put option spread by $0.0288 ($2.88 per contract). This Spider effect is -2.59% of the pre-listing mean spread of $1.6507 for call options and +1.82% of the pre-listing mean spread of $1.5776 for put options. Panels A and B of Table IV also show that the mean Spider effect is pervasive. Among call options, 78.36% of the 11,459 Spread_Diff figures are negative, while 64.21% of the 11,459 put option Spread_Diff figures are positive. However, the Spider effect is not that sizeable and lacks statistical significance. About 60% of the call Spread_Diff figures are in between -0.10 and 0.0 and approximately 46% of the put Spread_diff figures lie within 0.0 to +0.10. Similarly, the ratio of the mean to standard deviation of Spread_Diff is way less than 2.0 in magnitude indicating lack of statistical significance for a non-zero mean.

To summarize the spread effect, the listing of Spider options seems to have had differential but pervasive impacts on the S&P 500 call and put options. In general, the call spreads fell while the put spreads rose following the listing of Spider options, driven by a change in the positive marginal impact of premium level and the negative marginal impact of Money Bucket on the spreads. However, the overall effect on the conditional expectation of the spreads is neither sizeable nor statistically significant. From a methodological point of view, an important observation is that the direction of the effects in our multivariate Spread_Diff analysis is opposite to that of the univariate results in

[16] Money Bucket is on average significant at 10% for Put options in the post-listing period.

Table I. To recollect, the unconditional mean spreads in Table I showed an increase in the call spread and a decrease in the put spread in the post-listing period. This underscores the importance of taking into account the systematic relationship between the spreads and their various determinants, and any change in the marginal impacts of the determinants that is induced by the listing event.

While we found that the listing of Spider options affected the quoted bid-ask spread of S&P 500 Index options, the overall liquidity effect also depends on the volume consequences. Summary statistics for total option contract volume, total call option contract volume and total put option contract volume for the S&P 500 Index (SPX) are presented in Panels A (Total), B (Call) and C (Put) of Table V. In Panel D of Table V, the pre-listing and post-listing ratios of daily average put volume to daily average call volume are reported as estimates of put/call ratio before and after the listing of Spider options. For comparative purpose, we also present similar statistics for the S&P 100 Index options (OEX) in Panels E, F, G and H, and for the NASDAQ 100 Index options (NDX) in Panels I, J, K and L. All index option volume data were collected from the OptionMetrics database of the Wharton Research Data Services.

According to the CBOE 2005 Annual Report,[17] S&P 500 Index options volume hit a record high of 71.8 million contracts in 2005, exceeding the previous high in 2004 by 45%. Our evidence in Panels A (Total), B (Call) and C (Put) of Table V attest to this record pace of SPX volume. The average daily volume surged by 33.95% from 179,462 contracts in the pre-listing period (January 01, 2004 to January 09, 2005) to 240,398 contracts in the post-listing period (January 10, 2005 to June 30, 2005). Interestingly, in both periods, put option volume significantly outpaced call option volume and the growth in volume was also higher for put options. This led to estimated Put/Call Ratios (Panel D, Table V) of 1.82 and 1.90 before and after the listing of Spider options respectively, meaning an increase of 4.10% in the ratio. As can be discerned from the historical data in the CBOE 2005 Annual report, SPX put volume first exceeded call volume in 1990, OEX put volume first exceeded call volume in 1989, and the trend continued picking up some pace along the way.

In contrast to the high growth of daily contract volumes for S&P 500 Index options, the daily S&P 100 Index options volumes saw only moderate growth of about 17% (Panels E, F and G, Table V) from the pre-listing to the post-listing period. On the other hand, the daily NASDAQ 100 Index option volumes (Panels I, J and K, Table V) grew at a blazing pace of 92.71% (Total), 114.57% (Call) and 80.72% (Put) over the same period. While the estimated Put/call ratio remained unchanged for the S&P 100 Index options at 1.05 (Panel H, Table V), the ratio for the NASDAQ 100 Index options in fact declined by 16% from 1.82 in the pre-listing period to 1.53 in the post-listing period.

To place these volume results into the perspective of recent history, Table VI contains daily average option volume data for the most recent six years (2000 to 2005). The source of this data is the CBOE 2005 Market Statistics.[18] It appears that, in the year 2005 that includes our post-listing period, the growth of options volume is above average (2000 to 2004) for all three indexes. The average growth rates in total contract volume during 2000 to 2004 are 21.16% (SPX), 4.12% (OEX) and 24.23% (NDX), while the corresponding 2005 growth rates are 45.14% (SPX), 13.68% (OEX) and 79.71% (NDX). In fact the 2004 growth rates are also quite high compared to the preceding years.

In terms of the put/call ratio, the OEX is roughly balanced and unwavering at about 1.10, but the SPX and NDX have a historical bias in favor of put options at a put/call ratio value of 1.48. While the SPX and NDX put/call ratios have dropped off a bit in 2005, the overall recent trend seems upward.[19] To recollect, the figures in Table V showed similar behavior, except that during the post-listing period, approximately the first half of 2005, the relative volume of put options (Panel D) exhibited a continued increase. It is of interest to note that the Spider options have shown a clear and similar volume bias in favor of put options. In the month of their introduction in January, the Put/Call ratio was 2.01 (=593,882/294,998) and for the year 2005 the figure is 1.77 (=10,354,040/5,841,267).

Based on the discussion above, it seems that the SPX options volume change from the pre-listing to the post-listing period could be continuation of the trend in the index options markets. However, it can be claimed that the listing of Spider options did not seem to negatively affect, i.e., cannibalize the S&P Index options in terms of contract volume. Obviously, it would be helpful if we knew what would have been the volume of the S&P Index Options during the post-listing period in the absence of the Spider options.

[17] Source: http://www.cboe.com/AboutCBOE/AnnualReportArchive/AnnualReport2005.pdf.
[18] Source: http://www.cboe.com/data/marketstats-2005.pdf
[19] This minor deviation is perhaps due to the growing popularity and increasing use of the CBOE S&P 500 BuyWrite Index (BXM) Strategy, mentioned in the CBOE 2005 Annual Report. This strategy involves writing covered S&P 500 Index call options each third Friday of the month against a long portfolio of stocks in the S&P 500 Index.

Unfortunately, theoretical literature on index options volume is rather scarce. We, therefore, estimate the following regression equation to relate the S&P 500 call option contract volume (cvol) and put option contract volume (pvol) separately to a set of market variables that are believed to be correlated with the respective S&P 500 option volume:

$$\ln[vol(t)] = \beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)] + \gamma_0\, spydum + \gamma_1\, dum\_spxreturn + \gamma_2\, dum\_vix + \gamma_3\, dum\_oexvol + \gamma_4\, dum\_ndxvol + \gamma_5\, dum\_ldepvol \quad (2)$$

SPX_return is the percentage change (in decimal) in the S&P 500 Index level; OEX_vol is the option contract volumes (call/put) for the S&P 100 Index; and NDX_vol is the option contract volumes (call/put) for the NASDAQ 100 Index. In general, call (put) option volumes tend to rise in a rising (falling) market while the total contract volume effect is uncertain. The market volatility index VIX is widely used as a technical indicator of market mood and impending market moves, and as such may affect S&P 500 option volumes. However, the marginal impact of VIX on S&P 500 option volume is a priori uncertain. The option volumes of other indexes such as the S&P 100 and the NASDAQ 100 are expected to capture the general trend in index option market activity and the lagged dependent variable is there to pick up any additional trend unique to the S&P 500 index option activity.

The dummy variable spydum takes on a value of 1.0 in the period following the listing of Spider options (i.e., January 10, 2005 and onward) and 0.0 otherwise. To identify possible changes in the effects of the market variables in the post-listing period, all the market variables are multiplied by spydum to create the interactive regressors (dum_spxreturn, dum_vix, ..).

Similar to spread analysis, we define the following conditional expectations for each volume measure:

$$Vol_t(A) = \exp\{\beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)] + \gamma_0\, spydum + \gamma_1\, dum\_spxreturn + \gamma_2\, dum\_vix + \gamma_3\, dum\_oexvol + \gamma_4\, dum\_ndxvol + \gamma_5\, dum\_ldepvol\}$$

$$Vol_t(B) = \exp\{\beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)]\}$$

$$Volume\_Diff_t = Vol_t(A) - Vol_t(B)$$

In these definitions, $Volume_t$ (B) is our prediction of the S&P 500 Index (call/put) options volume in the absence of any Direct or Indirect Effect of Spider options listing. Likewise, $Volume_t$ (A) is our prediction of the S&P 500 Index (call/put) option volume including any Spider options listing effect, Direct (change in Intercept) or Indirect (change in marginal effects of market variables). Accordingly, $Volume\_Diff_t$, is our measure of any Direct or Indirect Effect of Spider options listing on the conditional expectation of S&P 500 Index (call/put) option volume. The Volume_Diff for the S&P 500 total (call plus) option volume is calculated by summing the Volume_Diff estimates of call and put options. Unlike spread regressions, here the dependent variable (volume) is aggregated across all contracts and the regressors are also market or aggregated variables that are not contract specific. As a result, there is only time series dimension to the regression and we are able to easily combine the estimation of pre-listing and post-listing regression functions in one equation.

Since daily data for volume and other market variables are available dating back to 1996, we estimate the volume equations using alternatively the December 30, 2003 to June 06, 2005 period and the January 01, 1996 to June 06, 2005 period. This is to see if the volume effect is robust with respect to the choice of the pre-listing period. With respect to functional form of the regression equations, we chose the logarithmic form to model potential nonlinearity in the relationships and to control for level-related heteroskedasticity.

As the results for the alternative estimation periods are quite similar, only the shorter period (December 30, 2003 to June 06, 2005) regression results are presented in Table VII. Panel A(B) contains call(put) volume regression results. Given that we are dealing with noisy daily data, the R-Square values of 56.48% (call volume) and 53.22% (put volume) seem respectable, and as indicated by the probability value of the F statistics, both regression relationships are statistically significant. With the exception of SPX Return in put volume regression, the statistical significance of all other market variables is quite high. The volume effect of VIX is negative. The VIX level was historically high during the 1990s and the early 2000s and has come down considerably since that time while the index options volume kept rising. The positive volume associations with the largest (OEX) and the relatively more volatile (NDX) segments of the market confirm a general index volume effect as observed in Table V, while the positive lagged effect shows SPX-specific momentum in volume. The positive (negative) coefficient of SPX Return in the call (put) volume equation shows the usual popularity of call (put) options in rising (falling) markets.

The Intercept is positive and highly statistically significant in both equations. As shown by the coefficient of the dummy variable spydum, the Intercept changed by –6.84 (Panel A, call volume), and +1.25 (Panel B, put volume). However, these direct listing effects have rather large standard errors and as such are not statistically significant. The coefficients of all the interactive regressors lack statistical significance too.

In Table VIII, we present the summary statistics for Volume_Diff (call, put, total) in Panel A and its cumulative frequencies (%) in Panel B. Consistent with the large changes in the Intercept, Volume_Diff is, on average, negative (–13,903) for call options volume and positive (+8,920) for put option volume. The net effect is a negative average (–4,983) for for total (call plus put) option volume. Thus, on average, the listing of Spider options led to an increase in the S&P 500 put options volume that is outweighed by the decline in S&P 500 call options volume. In other words, while the S&P 500 options volume actually kept increasing during the post-listing period, the increase would have been lower for the S&P 500 put option volume and higher for the S&P 500 call option and total option volume in the absence of Spider options. In percentage terms, the Spider effect on volume is (21.86% (call), +7.70% (put) and (2.78% (total) of the respective pre-listing average daily volumes. Despite the sharp negative impact on call option volume, the total volume effect is muted due to the dominance of S&P put options trading.

The frequency distribution shows that these effects are pervasive. On 72.55% of the 102 trading days during January 10, 2005 to June 06, 2005, the S&P call options volume is lower than what it we would conditionally expect in the absence of Spider options. The put options volume, on the other hand, enjoyed a Spider boost on 82.35% of the trading days in the same period. Unlike the spread effect, the volume effect is not concentrated in smaller changes. On about half (48%) of the days, the aggregate call volume drop off is more than 20,000 contracts where the pre-listing average daily volume was about 63,587 contracts (Table V). For put options, the volume boost is more than +10,000 contracts on about half (51%) of the days and one third of the days the volume increase is 10,000 to 20,000 contracts, relative to a pre-listing average daily volume of 115,876 contracts. The extent of evidence on volume change is, however, weakened by the ratio values of mean to standard deviation of Volume_Diff that are way below 2.0 due to the large standard deviations.

We can conclude that the listing of Spider options perhaps cannibalized the overall S&P 500 options market a little. There is, however, pervasive and yet statistically weak evidence that the Spider options listing may have added to the increasing popularity of the S&P 500 index put options relative to the call options. The fact that the Spider options themselves also have a significant volume bias in favor of put options suggests possible cross-hedging related boost for the S&P 500 put options. On the other hand, speculative and/or covered writing (against Spiders) uses of index call options, especially by the retail investors, might have switched in part to Spider call options.

To summarize our liquidity findings so far, Spider options listing led to wider (narrower) spreads for S&P 500 Index put (call) options and there is good deal of evidence of strengthening (weakening) put (call) volume. As wider spread increases transaction cost and hence means poorer liquidity while increased volume improves liquidity, (holding depth constant), the net liquidity effect of Spider options listing on the S&P 500 Index options market is not clear. On the other hand, a combination of wider (narrower) spreads and increased (weaker) volume clearly boosts (dampens) the revenue of the option market makers. As such, Spider options listing appears to have improved market making revenue for S&P 500 put options while reducing the same for S&P 500 call options. Given the dominance of S&P 500 put options trading over call options and the fact that the change in spread applies to all contracts traded, not just the change in volume, it is likely that the aggregate revenue for the S&P 500 options market makers increased due to Spider options listing. The following rough estimate of change in daily market making revenue shows this.

	Call	Put	Net
Mean Spread_Diff x Mean Post-listing Daily Contract Volume	-$0.0427 63,587	$0.0288 115,876	
=Estimated Spread Revenue Change	-$271,793	$333,513	$61,720

The exchange fee revenue for the CBOE is roughly prorated to the contract volume. As such the CBOE likely suffered a little in terms of exchange fee revenue due to the net negative impact of Spider options listing on the total options volume of the S&P 500 Index options. Against the backdrop of the gains for the option market makers and the small loss for the CBOE, the liquidity benefit for the investors appears uncertain at best.

Thus the pre-listing concerns of the CBOE and McGraw-Hill (parent of Standard Poor's) about the harmful effects of cross-exchange competition on the reward for organizing index related options products appear exaggerated. At the same time, the liquidity and transaction cost benefits of cross-exchange competition for the investors, as claimed by the ISE and other competing exchanges, are also doubtful.

From academic point of view, our evidence of the lack of a clear liquidity benefit, especially the increase in S&P 500 put option spreads, contradicts prior findings. One possible reason is the way we measure the spread effect of (Spiders option) listing. If we just consider the change in Intercept like prior studies, there is evidence that the Intercept decreased for both call and put options, in line with prior research. This evidence is, however, weak since the Intercept does not appear to be significantly different from 0.0 in either the pre-listing or the post-listing period.[20]

Previous studies control for changes in the values of the included explanatory variables in the post-listing period, but not in their marginal effects. Our premise here is that the listing event can change these marginal effects and our evidence shows that this indeed is the case in our regression results for some of the included variables. After all, we are really interested in how the conditional expectation of spread changes because of the listing event, given the same set of values for the regressors or included variables in the post-listing period. The included variables and the Intercept merely allow us to model the conditional expectation.

We have also used all included regressors, statistically significant or not, in forming conditional expectation of the spread in the post-listing period. It is well-known that correlated variables may jointly have greater explanatory power although some of their coefficients may lack statistical significance due to larger standard errors of coefficients. The explanatory variables in our regression are correlated due to the nature of option valuation. For example, premium level is higher for in the money options (higher value of money bucket dummy) and the index volatility is an input into the premium level, the

[20] From a statistical point of view, the difference between two parameter estimates may have significant t-statistic although individually the parameters may not be found significantly different from 0.0. This is because the difference in parameter estimates may have a lower standard error.

option price volatility measure and option gamma.[21] To the extent, spreads are also affected by other option greeks such as theta and vega,[22] the index volatility also influences the regression Intercept via the mean effect of omitted variables.

A second methodological reason for conflicting evidence is that we run cross-sectional spread regression on a daily basis and then look at the pre-listing and post-listing distributions of the regression parameters, their t statistic and probability values. This is feasible here given the availability of sufficiently large number (90+) of S&P 500 call and put closing quotes on a daily basis even after the standard filters being applied. Thus, our estimation method is more general allowing for variations in the parameter values and their significance tests on a day-to-day basis.

On a different note, it is possible that the uniqueness of the S&P 500 Index options market compared to other index options and equity options markets played a role in producing different results. Certainly the institutional demand for S&P 500 Index put options for portfolio insurance purposes has always been a distinguishing feature of this market. Thus it may not be surprising that our put options spread results are different from prior evidence on the effect of increased competition.

Lastly, our investigation is about the effect of a particular type of increased competition, namely the availability of trading in comparable, but not identical (index) option products. In contrast, increased competition in the existing studies resulted from additional trading venues for the same option product. Thus, our evidence is perhaps not quite comparable to that reported in prior research; instead the findings here concern a novel event of comparable derivative products.

B. Impact of Spider Options on the Liquidity of SPX Option Buckets

So far we have examined the liquidity effects averaged over all levels of moneyness and maturity. It is of course possible that the effects of Spider options listing vary across option buckets. To measure the Spider effect at the option bucket level, we use the Spread_Diff measure for all option observations classified into a bucket. Estimating the regression coefficients at the bucket level may not be reliable since some option buckets do not typically attract that much volume. Further, our screening process has led to a small

[21] Please see Appendix A for the correlation of the spread regressors in Equation (1).

number of data points in some option buckets. In addition to this problem of data deficiency, the predictors that we used in estimating the regression relationship at the aggregate volume level are themselves market level variables, not specific to any option bucket feature. Of course, there is not much theoretical guidance either for option volumes at the bucket level. Accordingly, we restrict our option bucket results to the spread effect (Spread_Diff) only.

The bucket statistics reported in Table IX are: mean spread effect, standard deviation of spread effect, the ratio of mea to standard deviation of spread effect as a proxy for the t-statistic, the mean spread effect as a percentage of the mean pre-listing spread, and the number of data points or option quote observations (N). Panel A or left hand side of Table IX presents statistics for the S&P 500 call option buckets while Panel B or the right hand side contains statistics for the S&P 500 put option buckets. For the sake of completeness, we also include the mean pre-listing and post-listing contract volumes for each bucket. Detailed statistics on the actual pre-listing and post-listing spread, percentage (of premium) spread, contract volumes by option buckets are in Appendices B and C for call and put options respectively.[23] Summary statistics on the moneyness, maturity and implied volatility of the buckets follow in Appendices D and E.

To recollect, we have twenty buckets of call options and twenty buckets of put options, arising from four maturity classes (Near, Short, Medium and Long) and five moneyness (S/K) ranges (DOTM, OTM, ATM, ITM and DITM). However, the Near maturity DOTM (DITM) call (put) option bucket does not have any data point in our post-listing screened sample.

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[22] Option greeks refer to the partial derivatives of option value with respect to its various determinants. Theta is the partial with respect to time and vega is the partial with respect to the index volatility.

[23] In academic research on the modeling of S&P 500 index option prices, some studies have principally relied on dollar pricing errors to exhibit modeling improvements, especially for shorter maturity OTM and DOTM options where the full premium reflects speculative value and it can be sensitive to proper modeling of the tail probabilities. Our dollar spread results here can be used as a guide to evaluate the economic significance of such modeling improvements. For example, for short maturity OTM call options, the mean quoted spread is $0.61 over the January 01, 2004 to June 30, 2005 period. Any economically significant modeling exercise to fit the S&P 500 Index call option prices over this period should target about $0.305 or higher for a reduction in pricing error for this bucket. Otherwise, the improved model prices would still be within the spread and cannot be practically used for trading on temporary misevaluations in the market. It is also to be noted that if models are fitted to older datasets, the dollar pricing improvements may not apply to recent option prices if the index and volatility levels have shifted significantly during this time leading to much different premium levels and hence spreads. Accordingly, it will be more useful if modeling improvement results are shown in terms of dollar as well percentage pricing errors, so that their economic significance can be judged properly and at different times.

Averaging the Spread_Diff measure across all S&P 500 option observations in the post-listing period, we reported earlier (Table IV) that the spread effect of Spider options listing is ($0.0427 for call options and +$0.0288 for put options. In terms of frequency, we found the spread effect to be negative for 78.36% of call option quotes and to be positive for 64.21% of put option quotes. The mean spread figures in Table IX confirm these patterns of the spread effect at the option bucket level. As we look at Panel A of Table IX, the mean spread effect is negative for 16 out of the 19 call option buckets for which we have data points in the screened sample. The 16 negative mean spread buckets belong to short, medium and long maturity classes, while the 3 positive mean spread buckets are all near term options. As a proxy for t-test of the null hypothesis of a 0.0 mean, the magnitude of the ratio of mean to standard deviation of spread effect exceeds the value of 2.00 in 9 (mostly medium and long maturity) out of the 16 negative spread call buckets and 1 (near maturity DITM) out of 3 positive spread call buckets. As a percentage of the mean pre-listing spread, the spread effect varies from (2.97% (Long ATM) to (6.29% (Long DITM) among the 9 buckets where the mean magnitude is more than two times the standard deviation.

Panel B of Table IX shows that the mean spread effect is positive for 14 out of the 19 put option buckets. All medium and long maturity buckets, the short maturity DITM, ITM and DOTM buckets, and the near maturity DOTM bucket make up the group of 14 positive mean spread buckets. The 5 negative spread buckets are the remaining short and near maturity buckets. As a proxy for t-test of the null hypothesis of a 0.0 mean, the magnitude of the ratio of mean to standard deviation of spread effect exceeds the value of 2.00 in 8 (mostly medium and long maturity) out of the 14 positive spread put buckets and 1 (near maturity ATM) out of 5 negative spread put buckets. As a percentage of the mean pre-listing spread, the spread effect varies from +3.37% (Medium ITM) to +11.11% (Long DITM) among the 8 buckets where the mean magnitude exceeds two times the standard deviation.

In terms of contract volume, some of the more popular buckets are ATM and OTM call options, and ATM, OTM and DOTM put options. These popular categories experience the same general trend in their respective types, negative spread effect for call options and positive spread effect for put options. But the magnitude of the spread effect for these popular types is relatively modest. Previously, Mayhew (2002) noted the spread effect to be small for most actively traded cross-listed equity options. Also, according to Neal (1987) and De Fontnouvelle et al (2003), the spread effect of cross-listing of equity options is most dominant for low volume options.

It is, however, worth noting that the buckets with sizeable spread effect in our study are not all low activity per se. Among this group, for example, long maturity OTM and ATM call options, and long maturity ATM, OTM and DOTM put options saw moderate volume in the pres-listing period and a large increase in post-listing volume.

Overall, the narrowing of call spread and the widening of put spread following the listing of Spider options appear widespread and sizeable among many option buckets.

C. Impact of Spider Options on the Pricing Structure of SPX Options

The pricing structure of options is most suitably captured by the behavior of implied volatilities across different strike prices for a given maturity or across maturities for a given strike price or moneyness. It is a standard practice to calculate implied volatilities using the Black-Scholes-Merton model of European option valuation. S&P 500 Index option implied volatilities across strike prices have often been found to exhibit patterns similar to some variant of a smile. These volatility smiles have been subject to intense scrutiny in academic research as well as in the industry. A common view on volatility smile is that it is generated by deviations from lognormal distribution of index returns under the arbitrage-free measure, and the most cited reason for these deviations is the stochastic nature of index return volatility. A less popular but more recent view is that index option prices cannot be quite priced by arbitrage due to limits to arbitrage and other market frictions (e.g., Liu and Longstaff (2000), Shleifer and Vishney (1997)). Under such circumstances, like other financial securities and commodities, demand and supply conditions will affect the pricing of index options and thus their implied volatility patterns. As noted by Bollen and Whaley (1994), the demand and supply effects are likely to be higher for the S&P 500 Index options where public orders are concentrated on one side, either demand or supply. The most well-known of such imbalances is the lop-sided demand for the S&P 500 Index put options by institutional investors for portfolio insurance purposes.

Our purpose here is to study if and how the listing of Spider options affected the volatility smile, i.e., pricing structure, of the S&P 500 Index options. If the availability of Spider options significantly changes the demand and supply of the S&P 500 Index options, we may expect some change in the pattern of S&P 500 volatility smile, according to the arguments of Bollen and Whaley (2004). Second, it is possible that the S&P 500 Index options were not enough to insure against all relevant market risks, at least for some important segment of market participants. To the extent the Spider options make it possible, the fundamental pricing kernel may change instigating a change in the S&P 500 volatility smile. Lastly, although we do not study this matter in this paper, availability of Spider options may also affect the underlying return process of the S&P 500 Index and Spiders.

Volatility smile curve is usually generated for a continuum of strike prices based on estimated parametric or nonparametric function for the curve. To get a rough idea though, we first generate a curve based on the mean implied volatilities of our option buckets. The implied volatilities are the mid-quote Black-Scholes-Merton implied volatilities from the OptionMetrics database of Wharton Research Data Services. We omit the put implied volatilities in our reporting as the results are almost the same, as expected due to the put-call parity relationship of European options.

The summary statistics by option buckets are available in Tables X. However, as is customary for volatility smiles, we focus on the corresponding graphs. In Figure 1, we plot the mean pre-listing and post-listing implied volatilities of SPX call options against the five strike price ranges, separately for each of the four maturity classes. To evaluate the effect of Spider options, we then compare the pre-listing and post-listing smiles. It is quite clear from Figure 1 that the listing of Spider options didn't materially change the volatility smile of SPX options. As in the pre-listing period, we observe a largely downward sloping post-listing smile curve. Consistent with earlier report on CBOE Volatility Indices (Panels E and F, Table II), the SPX smile curves have essentially shifted down in almost a parallel fashion.

The smile curve in Figure 1 is drawn by connecting the mean implied volatilities of just 4 to 5 strike buckets for each maturity class. There is also no control for time to maturity differences within a maturity class. We, therefore, estimate the following (double log) implied volatility surface equation:

$$\ln (V_{i,t}) = \beta_{0,t} + \beta_{1,t} \ln (S_t/K_i) + \beta_{2,t} \ln (T_i) \quad (3)$$

where St is the S&P 500 Index closing value on day t, option i has a strike of Ki and time to maturity Ti as of day t, and Vi,t is the mid-quote Black-Scholes-Merton implied volatility of option i on day t. Each trading day during the sample period, Equation (3) is estimated, using Ordinary Least Squares (OLS) method, once using only the call option observations available for the day in our screened sample and then using only the available put option observations.

For a continuum of strike prices between 0.714 (S/K=1.40) and 1.667 (S/K=0.60) with the index value normalized to 1.0, and for a given maturity (15, 90, 180, or 270 days), we generate two implied volatility smile curves, one for the pre-listing period (IVOL_PRE) and one for the post-listing period (IVOL_POST). For each period, the mean daily parameter estimates are used in Equation (3) to generate the curve. This leads to four call and put option implied volatility curves for the four maturities. Since as expected the curves are almost identical for call and put options, we only report here the call option smile curve in Figure 3. For all maturities, the parametric smile slopes downward and also confirms our previous observation of a largely parallel downward shift in the smile curve. The positive average slope coefficient of ln(S/K) causes the negative slope and the lower mean of intercept values in the post-listing period captures the downward shift.

While there is no pronounced change in the shape of the implied volatility smile from the pre-listing period to the post-listing period, the post-listing call smile curves are a bit steeper than their pre-listing counterparts, as is also evident from the higher post-listing mean for the coefficient ($\beta_{1,t}$) of ln(S/K). To further investigate the surface estimation results, we plot the daily estimates of $\beta_{1,t}$ and the R-Square% in Figure 5. The degree of fit and the slope coefficient of the volatility surface show time variations that appear random on a day to day basis. The R-Square% varies around a respectable level of 80% with a bit more variation in the post-listing period. Thus the degree of fit does not seem to be systematically different between the pre-listing and the post-listing periods. We do not see any discernible strong pattern in $\beta_{1,t}$, but it appears trending slightly higher in the post-listing period. This is pretty much what we observed in the mean parameter estimates.

Overall we do not find any major effect of Spider options listing on the volatility smile pattern of the S&P 500 Index options. The observed downward shift is likely a market phenomenon noted earlier (Table II) in the index options markets. This conclusion does not seem to be driven by poor fits or by differential quality of estimation in the pre-listing and the post-listing periods.

III. Summary and Conclusions

After a long wait and much debate, January 10, 2005 marked the beginning of trading in options on the popular Exchange Traded Fund, S&P 500 Depository Receipt, known as Spider. Although Spider options are not identical to the S&P 500 Index options, they do provide a very liquid alternative to and as such competition for the S&P 500 Index options. In this paper, we investigated if the availability of Spider options had any impact on the S&P 500 Index options market in terms of liquidity (bid-ask spread and volume) and pricing (implied volatility curve). For this purpose, we examined the end of day quoted bid-ask spread and the mid-quote Black-Scholes-Merton implied volatility for various strikes and maturities, and the aggregate daily call and put volume of the S&P 500 Index options, before (January 01, 2004 to January 09, 2005) and after (January 10, 2005 to June 30, 2005) the listing of Spider options.[24]

To measure the spread effect of Spider options listing, we use the difference in the conditional expectation of the post-listing spreads in a standard regression framework, when using the post-listing versus the pre-listing Intercept and slope coefficients. For the volume effect, a similar methodology is used. As for the option pricing effect, we compare pre-listing and post-listing implied volatility curves that are generated using average parameter values, in the respective periods, of the implied volatility surfaces estimated daily.

Our main findings are summarized here. First, using the measure of spread effect proposed in this paper, we find the Spider options listing to affect the spreads of the S&P 500 call and put options in an opposite manner. While call spreads narrowed by $0.0427 (2.59% of pre-listing mean spread) or $4.27 per contract, put spreads widened by $0.0288 (1.82% of pre-listing mean spread) or $2.88 per contract. The spread effect is neither sizeable nor statistically significant, but it is nonetheless pervasive. The spread narrowed

[24] Post-listing period for the aggregate volume analysis is January 10, 2005 to June 06, 2005.

for 78.36% of the 11,459 call option quotes, while 64.21% of the same number of put option quotes had the spread widening.

Second, based on our volume effect measure, increased competition from the Spider options actually boosted the average daily volume of the S&P 500 put options by 8,920 contracts. On the other hand, the average S&P 500 call volume dropped off by 13,903 contracts, leading to a net decline of 4,983 contracts in total (call plus put) options volume. As a percentage of pre-listing daily average volume, the volume effects are –21.86% (call), +7.70% (put) and –2.78% (total). The call and put volume effects are pervasive as well as sizeable. The put volume effect is positive on 82.35% of the 102 post-listing trading days in volume analysis, while the call volume effect is negative on 72.56% of these days. On about half of the days, the put volume increase exceeds 10,000 contracts and the call volume decline is worse than 20,000 contracts. Still, the volume effects are not statistically significant due to their large daily variations.

Third, the well-known implied volatility smile of the S&P 500 Index options remains in tact, although the curves have shifted down as part of a general decline in the index option markets in the post-listing period. It seems that, from an asset pricing point of view, the availability of similar option products on the market portfolio does not affect the fundamental pricing kernel. In this sense, the theoretical premise of the pricing redundancy of additional derivative securities in a frictionless/complete market seems to hold in the real world that departs from this ideal setup. However, there are important welfare implications of our findings in terms of market microstructure and competition. Prior studies (e.g., De Fontnouvelle et al (2003), Mayhew (2002), George and Longstaff (1993), and Neal (1987)) find increased competition among exchanges for the same option product leads to lower transaction costs for the investors in the form of lower spreads. Unfortunately for the S&P 500 Index put options investors, we find the spread component of the transaction cost to go up despite increasing volume. For the call options, the opposite is the case. Considering both spread and volume consequences, it is not clear whether investors benefited in terms of overall liquidity due to increased competition from Spider options. Given the overall volume boost and the enhanced spread for the more active put options, ironically the S&P 500 option market makers got a boost in revenue from the effective relaxation of the exclusive licensing for S&P 500 products. The CBOE's loss in fee revenue from a net decline in total options volume is rather minor.

Accordingly, we find that the CBOE and McGraw-Hill argument about the necessity of exclusive licensing for profitable organization of the marketplace for innovative products is at least exaggerated. On the other hand, the argument from the competing exchanges like the ISE that relaxation of exclusive licensing and increased competition will reduce the transaction costs for the investors is not quite supported either.

Overall, we find increased competition from the Spider options to be a benign development. There is no dramatic change in either the microstructure or the pricing of the S&P 500 Index options. There is no clear cut big winner or loser either.

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Table I
Summary Statistics for S&P 500 Index Option Bid-Ask Spread

This table reports summary statistics for the dollar bid-ask spread and the percentage bid-ask spread (=100*dollar bid-ask spread/mid-quote) of the S&P 500 Index Call and Put Options. The bid and ask quotes are the daily closing best bid and best ask quotes from the OptionMetrics database of the Wharton research Data Services. The figures for "Overall" are calculated using the entire sample period, from January 01, 2004 to June 30, 2005. The figures for "Before" are calculated using observations prior to the listing of Spider options on January 10, 2005 and the figures for "After" are calculated using observations following the listing of Spider options. The figures for "Change" reflect the difference, Mean of "After" – Mean of "Before", and the "% Change" equals "Change"/ Mean of "Before".

A. S&P 500 Call Options — Dollar Bid-Ask Spread

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	1.666	0.672	40,492	0.05	4.00
Before	1.651	0.689	29,032	0.05	4.00
After	1.706	0.625	11,460	0.05	4.00
Change	0.055		*F Statistic*	*56.05*	
%Change	3.36		*Prob Value*	*<0.0001*	

B. S&P 500 Put Options — Dollar Bid-Ask Spread

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	1.523	0.711	40,492	0.05	5.00
Before	1.578	0.709	29,032	0.05	5.00
After	1.383	0.695	11,460	0.05	3.00
Change	(0.194)		*F Statistic*	*624.00*	
%Change	(12.31)		*Prob Value*	*<0.0001*	

C. S&P 500 Call Options — Percentage Bid-Ask Spread

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	7.362	10.105	40,492	0.09	133.33
Before	7.821	10.615	29,032	0.09	133.33
After	6.198	8.569	11,460	0.22	100.00
Change	(1.623)		*F Statistic*	*213.21*	
%Change	(20.75)		*Prob Value*	*<0.0001*	

D. S&P 500 Put Options — Percentage Bid-Ask Spread

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	9.464	10.038	40,492	0.14	116.67
Before	8.568	9.380	29,032	0.14	116.67
After	11.734	11.224	11,460	0.41	100.00
Change	3.166		*F Statistic*	*834.69*	
%Change	36.95		*Prob Value*	*<0.0001*	

Table II
Summary Statistics for S&P Index Option Price and Implied Volatility, and CBOE Volatility Indices

This table reports summary statistics for the Option Premium (Mid-Quote) and the Implied Volatility (based on Mid-Quote, in APR or Annual Percentage Rate) of the S&P 500 Index Call and Put Options, the daily closing values of the CBOE Volatility Indices VIX and VXO, and the daily Closing Value and Return (Proportionate Change in Closing Value, in decimal) for the S&P 500 Index. All data are from the Optiometrics database of the Wharton research Data Services. The figures for "Overall" are calculated using the entire sample period, from January 01, 2004 to June 30, 2005. The figures for "Before" are calculated using observations prior to the listing of Spider options on January 10, 2005 and the figures for "After" are calculated using observations following the listing of Spider options. The figures for "Change" reflect the difference, Mean of "After" – Mean of "Before", and the "% Change" equals "Change"/ Mean of "Before".

A. S&P 500 Call Options
Option Premium

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	65.677	57.846	40,492	0.28	231.60
Before	62.764	56.130	29,032	0.28	225.70
After	73.058	61.367	11,460	0.28	231.60
Change	10.294		*F Statistic*	*262.21*	
%Change	16.40		*Prob Value*	*<0.0001*	

B. S&P 500 Put Options
Option Premium

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	39.908	43.363	40,492	0.28	283.60
Before	45.635	47.601	29,032	0.28	283.60
After	25.401	24.702	11,460	0.28	139.20
Change	(20.234)		*F Statistic*	*1874.19*	
%Change	(44.34)		*Prob Value*	*<0.0001*	

C. S&P 500 Call Options
Implied Volatility, APR,Mid-Quote

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	15.815	3.853	40,492	7.42	50.64
Before	16.346	3.768	29,032	7.45	49.49
After	14.469	3.739	11,460	7.42	50.64
Change	(1.876)		*F Statistic*	*2045.92*	
%Change	(11.48)		*Prob Value*	*<0.0001*	

D. S&P 500 Put Options
Implied Volatility, APR,Mid-Quote

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	16.191	3.557	40,492	4.96	38.91
Before	16.718	3.490	29,032	4.96	38.44
After	14.856	3.372	11,460	6.21	38.91
Change	(1.861)		*F Statistic*	*2381.39*	
%Change	(11.13)		*Prob Value*	*<0.0001*	

E. CBOE Volatility Index
VIX, APR, Daily

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	14.838	2.031	359	11.100	21.580
Before	15.449	1.916	257	11.230	21.580
After	13.298	1.406	102	11.100	17.740
Change	(2.151)		*F Statistic*	*105.81*	
%Change	(13.92)		*Prob Value*	*<0.0001*	

F. CBOE Volatility Index
VXO, APR, Daily

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Before	14.799	2.126	359.000	11	21.71
After	15.534	1.917	257.000	11	21.71
Change	12.948	1.366	102.000	11	16.83
%Change	(2.586)		*F Statistic*	*154.33*	
% Change	(16.65)		*Prob Value*	*<0.0001*	

Table III
Regression Results for the S&P 500 Index Quoted Option Spreads

This table presents the averages of the regression parameters, their t-statistics and tw0-sided probability values (in decimal) , and the Regression Degrees of Freedom and R-Square% for Equation (1), estimated daily over the sample period of January 01, 2004 to June 30, 2005, separately for call and put options: $\ln(Spread_{i,t}) = \beta_0 + \beta_1 \ln(Contract\ Volume_{i,t}) + \beta_2 \ln(Option\ Premium_{i,t}) + \beta_3 \ln(Option\ Volatility_{i,t}) + \beta_4 \ln(Option\ Gamma_{i,t}) + \beta_5\ Money\ Bucket_{i,t}$. The subscript i.t refers to the i-th option on day t. Quoted Dollar Spread is the closing dollar quoted bid-ask spread, Contract Volume is the number of contracts traded, Option Premium is the middle of the closing bid and ask quotes, Option Volatility is the mid-quote Black-Scholes implied volatility times the absolute value of delta (using mid-quote Black-Scholes implied volatility), Option Gamma is the Black-Scholes gamma (using mid-quote Black-Scholes implied volatility), and Money Bucket is a dummy variable indicating option moneyness with values 1 (DOTM), 2 (OTM), 3 (ATM), 4 (ITM) and 5 (DITM). All data are from the Optiometrics database of the Wharton research Data Services. The "Mean Before" figures are calculated using observations prior to the listing of Spider options on January 10, 2005 and the "Mean After" figures are calculated using observations following the listing of Spider options. The figures for "Mean Change" reflect the difference, "Mean After" – "Mean Before", and the two-sided probability value for the t-test of Mean Change is conducted assuming unequal variances in the two periods.

S&P 500 Call Options					**S&P 500 Put Options**			
Mean Before	**Mean After**	**Mean Change**	**t Test of Mean Change Two- Sided Prob Value** (decimal)		**Mean Before**	**Mean After**	**Mean Change**	**t Test of Mean Change Two- Sided Prob Value** (decimal)
	Equation (1) for Call Options:			**A. Parameter Estimates**		**Equation (1) for Put Options:**		
0.3964	0.3365	-0.0599	0.3454	Intercept	0.7747	0.2951	-0.4796	0.0191
-0.0190	-0.0154	0.0037	0.0125	ln(Contract Volume)	-0.0217	-0.0193	0.0024	0.1289
0.5359	0.4699	-0.0660	0.0012	ln(Option Premium)	0.5710	0.6081	0.0371	0.2902
-0.0584	0.0790	0.1374	0.0000	ln(Option Volatility)	-0.1608	-0.2461	-0.0853	0.2723
0.1893	0.1766	-0.0127	0.1956	ln(Option Gamma)	0.2397	0.1666	-0.0731	0.0193
-0.1857	-0.2093	-0.0236	0.0005	Money Bucket	-0.1971	-0.1630	0.0341	0.0003
	Equation (1) for Call Options:			**B. t-Statistic of Parameter Estimates**		**Equation (1) for Put Options:**		
1.2814	1.4625	0.1811	0.4546	Intercept	1.0913	0.3421	-0.7492	0.0023
-1.7355	-1.4272	0.3083	0.0154	ln(Contract Volume)	-1.9411	-1.6424	0.2987	0.0208
6.0233	6.0168	-0.0066	0.9828	ln(Option Premium)	5.3067	5.3811	0.0744	0.8374
-0.1136	0.6026	0.7162	0.0001	ln(Option Volatility)	-0.2512	-0.7598	-0.5085	0.0231
2.9994	3.2236	0.2242	0.1862	ln(Option Gamma)	2.6330	1.4659	-1.1671	0.0000
-4.9000	-4.9859	-0.0858	0.6642	Money Bucket	-5.7057	-3.4973	2.2084	0.0000
	Equation (1) for Call Options:			**C. Probability Value of t-Statistic**		**Equation (1) for Put Options:**		
0.2454	0.2020	-0.0434	0.1598	Intercept	0.3218	0.3127	-0.0091	0.7989
0.2003	0.2665	0.0662	0.0258	ln(Contract Volume)	0.1601	0.2307	0.0705	0.0136
0.0065	0.0077	0.0012	0.7679	ln(Option Premium)	0.0139	0.0544	0.0404	0.0132
0.4033	0.2963	-0.1070	0.0010	ln(Option Volatility)	0.3477	0.2978	-0.0500	0.1490
0.0893	0.0472	-0.0421	0.0109	ln(Option Gamma)	0.1272	0.1755	0.0483	0.0542
0.0361	0.0039	-0.0322	0.0002	Money Bucket	0.0268	0.0630	0.0362	0.0382
	Equation (1) for Call Options:			**D. Regression Statistics**		**Equation (1) for Put Options:**		
106.96	89.49			Degrees of Freedom	106.97	89.49		
83.6048	81.3760	-2.2288	0.0124	R-Square %	81.5874	83.2199	1.6325	0.0450

Table IV.
Statistics for the Estimated Effect of Spider Options on the S&P 500 Index Quoted Option Spreads

This table presents summary statistics and cumulative frequency (%) for Spread_Diff, a proposed measure for the effect of the listing of Spider options on the quoted bid-ask spread of the S&P 500 Index options. Equation (1) is first estimated daily over the sample period of January 01, 2004 to June 30, 2005, separately for call and put options: $\ln(\text{Spread}_{i,t}) = \beta_0 + \beta_1 \ln(\text{Contract Volume}_{i,t}) + \beta_2 \ln(\text{Option Premium}_{i,t}) + \beta_3 \ln(\text{Option Volatility}_{i,t}) + \beta_4 \ln(\text{Option Gamma}_{i,t}) + \beta_5 \text{ Money Bucket}_{i,t}$. The subscript i.t refers to the i-th option on day t. Then two alternative predicted values of the spread for all option observations in the post-listing period (January 10, 2005 to June 30, 2005) are calculated:

$\text{Spread}_{i,t}\text{ (A)} = \exp\{\beta_0^{Post} + \beta_1^{Post} \ln(\text{Contract Volume}_{i,t}) + \beta_2^{Post} \ln(\text{Option Premium}_{i,t}) + \beta_3^{Post} \ln(\text{Option Volatility}_{i,t}) + \beta_4^{Post} \ln(\text{Option Gamma}_{i,t}) + \beta_5^{Post} \text{ Money Bucket}_{i,t}\}$

$\text{Spread}_{i,t}\text{ (B)} = \exp\{\beta_0^{Pre} + \beta_1^{Pre} \ln(\text{Contract Volume}_{i,t}) + \beta_2^{Pre} \ln(\text{Option Premium}_{i,t}) + \beta_3^{Pre} \ln(\text{Option Volatility}_{i,t}) + \beta_4^{Pre} \ln(\text{Option Gamma}_{i,t}) + \beta_5^{Pre} \text{ Money Bucket}_{i,t}\}$

In the above definitions of $\text{Spread}_{i,t}$ (A) and $\text{Spread}_{i,t}$ (B), the β^{Pre} parameters are the averages of the 257 daily estimates in the pre-listing period (January 01, 2004 to January 09, 2005) and β^{Post} parameters are the averages of the 120 daily estimates in the post-listing period (January 10, 2005 to June 30, 2005). In both definitions, however, the actual daily post-listing values are used for the right hand side variables. $\text{Spread}_{i,t}$ (B) is our predicted spread for the i-th option on day t of the post-listing period if the β's in the post-listing period were on average the same as the pre-listing β's. On the other hand, $\text{Spread}_{i,t}$ (A) is our predicted spread for the i-th option on day t of the post-listing period using the average β's in the post-listing period. Using these two predicted values, we can now estimate the Spider Effect on the S&P 500 option spreads: $\text{Spread\_Diff}_{i,t} = \text{Spread}_{i,t}\text{ (A)} - \text{Spread}_{i,t}\text{ (B)}$.

A. Summary Statistics on Spread_Diff		
	Call	Put
N	11,459	11,459
Mean	-0.0427	0.0288
Stdev	0.0574	0.0772
Min	-0.1783	-0.2113
Max	0.1599	0.5666
% Negative	78.36	35.79
%Postitive	21.64	64.21

B. Cumulative Frequency (%) of Spread_Diff		
	Call	Put
<-0.2	0.00%	0.02%
-0.1 to -0.2	18.80%	5.56%
-0.1 to 0.0	78.36%	35.79%
0.0 to 0.1	99.33%	81.87%
0.1 to 0.2	100.00%	98.69%
0.2 to 0.3	100.00%	99.97%
0.3 to 0.4	100.00%	99.99%
0.4 to 0.5	100.00%	99.99%
>0.5	100.00%	100.00%

Table V
Summary Statistics for Option Volume of the S&P 500, S&P 100 and NASDAQ 100 Indexes

This table reports summary statistics for the daily total option volume and the total call and put option volumes separately for the S&P 500 (SPX), S&P 100 (OEX) and NASDAQ 100 (NDX) Indexes, before and after the listing of Spider options. All data are from the OptionMetrics database of the Wharton Research There are 257 trading days in the pre-listing period (January 01, 2004 to January 09, 2005) and 102 trading days in the post-listing period (January 10, 2005 to June 06, 2005) of this table due to the length of available volume information series for some index options.

A. S&P 500 Call and Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	196,776	76,078	359	56,168	514,483
Pre-Listing	179,462	61,164	257	56,168	424,996
Post-Listing	240,398	91,370	102	95,951	514,483
Change	*60,936*	F Statistic:	53.75		
% Change	*33.95*	P-Value:	<0.0001		

E. S&P 100 Call and Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	68,213	37,752	359	14,656	299,489
Pre-Listing	65,098	33,796	257	14,656	200,020
Post-Listing	76,061	45,497	102	23,665	299,489
Change	*10,963*	F Statistic:	6.25		
% Change	*16.84*	P-Value:	0.0129		

I. NDX Call and Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	29,819	27,741	359	4,789	233,661
Pre-Listing	23,602	20,376	257	4,789	142,595
Post-Listing	45,483	36,459	102	11,521	233,661
Change	*21,882*	F Statistic:	51.89		
% Change	*92.71*	P-Value:	<0.0001		

B. S&P 500 Call Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	69,098	30,272	359	19,634	199,258
Pre-Listing	63,587	26,153	257	19,634	197,364
Post-Listing	82,983	35,250	102	33,766	199,258
Change	19,396	F Statistic:	32.62		
% Change	30.50	P-Value:	<0.0001		

F. S&P 100 Call Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	33,213	20,048	359	6,601	134,957
Pre-Listing	31,704	18,305	257	6,601	134,957
Post-Listing	37,015	23,559	102	8,159	131,473
Change	*5,311*	F Statistic:	5.18		
% Change	*16.75*	P-Value:	0.0234		

J. NDX Call Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	11,085	9,546	359	1,253	94,954
Pre-Listing	8,363	4,837	257	1,253	30,546
Post-Listing	17,944	14,048	102	3,827	94,954
Change	*9,581*	F Statistic:	92.31		
% Change	*114.57*	P-Value:	<0.0001		

C. S&P 500 Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	127,678	52,225	359	36,534	379,443
Pre-Listing	115,876	41,889	257	36,534	294,172
Post-Listing	157,415	63,026	102	60,202	379,443
Change	41,540	F Statistic:	52.89		
% Change	35.85	P-Value:	<0.0001		

G. S&P 100 Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	35,000	20,298	359	7,760	197,493
Pre-Listing	33,394	17,540	257	7,760	117,042
Post-Listing	39,046	25,643	102	15,053	197,493
Change	*5,652*	F Statistic:	5.714		
% Change	*16.92*	P-Value:	0.0171		

K. NDX Put Options — Daily Volume, Overall Contracts

	Mean	*Standard Deviation*	*N*	*Min*	*Max*
Overall	18,734	21,743	359	2,586	181,085
Pre-Listing	15,239	18,179	257	2,586	127,756
Post-Listing	27,540	26,996	102	6,695	181,085
Change	*12,301*	F Statistic:	24.93		
% Change	*80.72*	P-Value:	<0.0001		

Put/Call Ratio Estimate: Mean Put Volume/Mean Call Volume

	D. S&P 500 Options	H. S&P 100 Options	L. NDX Options
Pre-Listing	1.82	1.05	1.82
Post-Listing	1.90	1.05	1.53
Change	0.07	0.00	(0.29)
% Change	4.10	0.15	(15.78)

Table VI
Option Volume of the S&P 500, S&P 100 and NASDAQ 100 Indexes: 2000-2005

This table reports daily average total option volume and the daily average call and put option volumes separately for the S&P 500 (SPX), S&P 100 (OEX) and NASDAQ 100 (NDX) Indexes. All data are from the CBOE 2005 Annual Report. The Mean figures are based on the years 200o to 2004.

A. S&P 500 Options (SPX)							
Daily Average Volume			**Put/Call**		**%Growth in Daily Average Volume**		
Total	**Call**	**Put**		Year	**Total**	**Call**	**Put**
284,931	*105,203*	*179,728*	*1.71*	*2005*	*45.14*	*49.09*	*42.92*
196,318	70,562	125,756	1.78	2004	34.60	15.02	48.81
145,852	61,345	84,507	1.38	2003	22.76	21.91	23.39
118,808	50,321	68,487	1.36	2002	21.40	22.76	20.41
97,868	40,990	56,878	1.39	2001	5.89	1.25	9.51
92,421	40,484	51,937	1.28	2000			
			1.48	*Mean*	*21.16*	*15.24*	*25.53*

B. S&P 100 Options (OEX)							
Daily Average Volume			**Put/Call**		**%Growth in Daily Average Volume**		
Total	**Call**	**Put**		Year	**Total**	**Call**	**Put**
74,099	*35,393*	*38,706*	*1.09*	*2005*	*13.68*	*11.57*	*15.67*
65,184	31,722	33,462	1.05	2004	14.52	14.29	14.73
56,921	27,755	29,165	1.05	2003	6.01	7.04	5.05
53,691	25,929	27,762	1.07	2002	28.04	32.84	23.86
41,932	19,518	22,414	1.15	2001	-32.08	-30.20	-33.63
61,736	27,965	33,771	1.21	2000			
			1.10	*Mean*	*4.12*	*5.99*	*2.50*

C. NASDAQ 100 Options (NDX)							
Daily Average Volume			**Put/Call**		**%Growth in Daily Average Volume**		
Total	**Call**	**Put**		Year	**Total**	**Call**	**Put**
25,163	*10,841*	*14,322*	*1.32*	*2005*	*79.71*	*105.82*	*63.96*
14,002	5,267	8,735	1.66	2004	117.45	129.17	110.94
6,439	2,298	4,141	1.80	2003	35.57	10.69	54.91
4,750	2,077	2,673	1.29	2002	-26.56	-24.74	-27.91
6,467	2,759	3,708	1.34	2001	-29.56	-26.09	-31.93
9,181	3,733	5,448	1.46	2000			
			1.48	*Mean*	*24.23*	*22.26*	*26.50*

Source: CBOE 2005 Annual Report
Mean: Average over 2001-2004.

Table VII
S&P 500 Index Option Volume Regression Results

This table reports regression results for the effect of Spider options listing on the total call option contract volume (cvol) and total put option contract volume (pvol). Each volume measure is regressed separately on a set of market variables, a dummy variable for Spider option listing and the set of interactive regressors as the product of the listing dummy and the market variables:

ln[vol (t)] = (0 + (1 ln[1+SPX_return (t)] + (2 ln[VIX (t)] + (3 ln[OEX_vol (t)]
+ (4 ln[NDX_vol (t)] + (5 ln[vol (t-1)] + (0 spydum + (1 dum_spxreturn
+ (2 dum_vix +(3 dum_oexvol + (4 dum_ndxvol + (5 dum_ldepvol (2)

SPX_return is the percentage change (in decimal) in the S&P 500 Index level; OEX_vol is the option contract volume (call/put) for the S&P 100 Index; and NDX_vol is the option contract volume (call/put) for the NASDAQ 100 Index. The dummy variable spydum takes on a value of 1.0 in the period following the listing of Spider options (i.e., January 10, 2005 and onward) and 0.0 otherwise. All the market variables are multiplied by spydum to create the interactive regressors (dum_spxreturn, dum_vix, ..). The sum of the last six right hand side terms with ('s captures the effect of Spider options listing on the conditional expectation of S&P 500 Index option volume. All data are from the OptionMetrics database of the Wharton Research Data Services. The volume equations are estimated using daily data over two alternative but overlapping estimation periods: December 30, 2003 to June 06, 2005 period and the January 01, 1996 to June 06, 2005 period. As the results are similar, we report here the results for the December 30, 2003 to June 06, 2005 period.

A. Period: December 30, 2003 to June 06, 2005					**B. Period: December 30, 2003 to June 06, 2005**			
Dependent Variable: ln(Call Option Volume)					**Dependent Variable: ln(Put Option Volume)**			
Parameter Estimate	Standard Error	t-Statistic	Pr > |t| (decimal)	**Equation 2:**	Parameter Estimate	Standard Error	t-Statistic	Pr > |t| (decimal)
5.02	0.55	9.18	<.0001	Intercept	5.62	0.56	9.97	<.0001
7.15	2.17	3.30	0.0011	ln[1+SPX_return(t)]	-2.26	2.11	-1.07	0.2860
-0.34	0.12	-2.80	0.0053	ln[VIX(t)]	-0.27	0.11	-2.47	0.0141
0.37	0.04	10.42	<.0001	ln[OEX_vol (t)]	0.32	0.04	8.94	<.0001
0.17	0.03	5.91	<.0001	ln[NDX_vol (t)]	0.13	0.02	5.61	<.0001
0.15	0.04	3.44	0.0006	ln[cvol (t-1)]	0.19	0.04	4.47	<.0001
-6.84	11.39	-0.60	0.5489	spydum	1.25	5.38	0.23	0.8160
7.44	23.13	0.32	0.7481	dum_spxreturn	1.81	12.81	0.14	0.8877
3.81	4.60	0.83	0.4079	dum_vix	0.28	2.11	0.13	0.8945
0.20	0.31	0.64	0.5231	dum_oexvol	-0.21	0.23	-0.89	0.3718
-0.41	0.32	-1.28	0.1997	dum_ndxvol	0.05	0.17	0.32	0.7491
-0.12	0.37	-0.34	0.7359	dum_ldepvol	-0.02	0.33	-0.07	0.9461
N	R-Square	F	Prob > F		N	R-Square	F	Prob > F
359	56.48	40.93	<0.0001		359	53.22	35.89	<0.0001

Table VIII

Statistics for the Estimated Effect of Spider Options on the S&P 500 Index Option Volume

This table presents summary statistics and cumulative frequency (%) for Volume_Diff, a proposed measure for the effect of the listing of Spider options on the total contract volume (tvol), call option contract volume (cvol) and put option contract volume (pvol) of the S&P 500 Index options. Each of call and put volume measure is regressed separately on a set of market variables, a dummy variable for Spider option listing and the set of interactive regressors as the product of the listing dummy and the market variables:

$$\ln[vol(t)] = \beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)] + \gamma_0\ spydum + (1\ dum\_spxreturn + (2\ dum\_vix + (3\ dum\_oexvol + (4\ dum\_ndxvol + (5\ dum\_ldepvol \quad (2)$$

SPX_return is the percentage change (in decimal) in the S&P 500 Index level; OEX_vol is the option contract volume (call/put) for the S&P 100 Index; and NDX_vol is the option contract volume (call/put) for the NASDAQ 100 Index. The dummy variable spydum takes on a value of 1.0 in the period following the listing of Spider options (i.e., January 10, 2005 and onward) and 0.0 otherwise. All data are from the OptionMetrics database of the Wharton Research Data Services. All the market variables are multiplied by spydum to create the interactive regressors (dum_spxreturn, dum_vix, ..). The sum of the last six right hand side terms with ('s captures the effect of Spider options listing on the conditional expectation of S&P 500 Index option volume. The volume equations are estimated using daily data over the December 30, 2003 to June 06, 2005 period. For each measure of volume (cvol, pvol), two alternative predicted or conditionally expected values of volume in the post-listing period (January 10, 2005 to June 30, 2005) are calculated:

$$Vol_t(A) = \exp\{\beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)] + \gamma_0\ spydum + \gamma_1\ dum\_spxreturn + \gamma_2\ dum\_vix + \gamma_3\ dum\_oexvol + \gamma_4\ dum\_ndxvol + \gamma_5\ dum\_ldepvol\}$$

$$Vol_t(B) = \exp\{\beta_0 + \beta_1 \ln[1+SPX\_return(t)] + \beta_2 \ln[VIX(t)] + \beta_3 \ln[OEX\_vol(t)] + \beta_4 \ln[NDX\_vol(t)] + \beta_5 \ln[vol(t-1)]\}$$

Using these two predicted values, we can now estimate the Spider Effect on the S&P 500 option spreads: $Volume\_Diff_t = Vol_t(A) - Vol_t(B)$. The Volume_Diff for total (call plus put) options volume is calculated by summing the Volume_Diff estimates of call and put options volume.

A. Summary Statistics on Volume_Diff			
	Call	Put	Total
N	102	102	102
Mean	-13,903	8,920	-4,983
Stdev	31,820	13,498	36,213
Min	-111,185	-58,197	-126,340
Max	98,673	37,095	78,246
% Negative	72.55	17.65	60.78
%Postitive	27.45	82.35	39.22

B. Cumulative Frequency (%) of Volume_Diff							
Thousands	Call	Put	Total	Thousands	Call	Put	Total
<-200	0.00%	0.00%	0.00%	0 tp +5	78.43%	27.45%	64.71%
-200 to -150	0.00%	0.00%	0.00%	+5 to +10	80.39%	49.02%	70.59%
-150 to -100	0.98%	0.00%	1.96%	+10 to +20	87.25%	83.33%	77.45%
-100 to -50	8.82%	1.96%	8.82%	+20 to +30	92.16%	99.02%	83.33%
-50 to -40	10.78%	1.96%	9.80%	+30 to +40	95.10%	100.00%	87.25%
-40 to -30	27.45%	1.96%	14.71%	+40 to +50	95.10%	100.00%	93.14%
-30 to -20	48.04%	1.96%	29.41%	+50 to +100	100.00%	100.00%	100.00%
-20 to -10	60.78%	5.88%	46.08%	+100 to +150	100.00%	100.00%	100.00%
-10 to -5	64.71%	7.84%	54.90%	+150 to +200	100.00%	100.00%	100.00%
-5 to 0	72.55%	17.65%	60.78%	>+200	100.00%	100.00%	100.00%

Table IX. Effect of Spider Options Listing on the Bid-Ask Spread of the S&P 500 Index Call and Put Option Buckets

This table reports summary statistics for the effect of Spider options listing on the quoted dollar bid-ask spread and the pre-listing and post-listing contract volume of S&P 500 Index Option buckets. For the i-th option series on day t, the bid-ask spread effect is measured by $Spread\_Diff_{i,t} = Spread_{i,t}\,(A) - Spread_{i,t}\,(B)$. Equation (1) is first estimated daily over the sample period of January 01, 2004 to June 30, 2005, separately for call and put options: $\ln(Spread_{i,t}) = \beta_0 + \beta_1 \ln(Contract\ Volume_{i,t}) + \beta_2 \ln(Option\ Premium_{i,t}) + \beta_3 \ln(Option\ Volatility_{i,t}) + \beta_4 \ln(Option\ Gamma_{i,t}) + \beta_5\ Money\ Bucket_{i,t}$. Then two alternative predicted values of the spread for all option observations in the post-listing period (January 10, 2005 to June 30, 2005) are calculated:

$Spread_{i,t}\,(A) = \exp\{\beta_0^{Post} + \beta_1^{Post} \ln(Contract\ Volume_{i,t}) + \beta_2^{Post} \ln(Option\ Premium_{i,t}) + \beta_3^{Post} \ln(Option\ Volatility_{i,t}) + \beta_4^{Post} \ln(Option\ Gamma_{i,t}) + \beta_5^{Post}\ Money\ Bucket_{i,t}\}$

$Spread_{i,t}\,(B) = \exp\{\beta_0^{Pre} + \beta_1^{Pre} \ln(Contract\ Volume_{i,t}) + \beta_2^{Pre} \ln(Option\ Premium_{i,t}) + \beta_3^{Pre} \ln(Option\ Volatility_{i,t}) + \beta_4^{Pre} \ln(Option\ Gamma_{i,t}) + \beta_5^{Pre}\ Money\ Bucket_{i,t}\}$

In the above definitions of $Spread_{i,t}$ (A) and $Spread_{i,t}$ (B), the β^{Pre} parameters are the averages of the 257 daily estimates in the pre-listing period (January 01, 2004 to January 09, 2005) and β^{Post} parameters are the averages of the 120 daily estimates in the post-listing period (January 10, 2005 to June 30, 2005). In both definitions, however, the actual daily post-listing values are used for the right hand side variables.

The number of trading days in our screened post-listing sample where closing bid and ask quotes are available for options belonging to a bucket is denoted by N. Contract Volume is the daily number of contracts traded for options belonging to a bucket. The pre-listing period is January 01, 2004 to January 09, 2005, and the post-listing period is January 10, 2005 to June 30, 2005.

Strike buckets are: deep in the money (DITM) call and deep in the money (DOTM) put, $S/K \geq 1.075$, in the money (ITM) call and out of the money (OTM) put, $1.025 < S/K \leq 1.075$, at the money (ATM) call and put, $0.975 < S/K \leq 1.025$, out of the money (OTM) call and in the money (ITM) put, $0.925 < S/K \leq 0.975$, and deep out of the money (DOTM) call and deep in the money (DITM) put, $S/K \leq 0.925$. Maturity buckets in terms of days are: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).

	A. S&P Index Call Options					B. S&P 500 Index Put Options				
	NEAR	SHORT	MEDIUM	LONG		NEAR	SHORT	MEDIUM	LONG	
DOTM		-0.0206	-0.0344	-0.0510	Mean Spread Effect		0.1768	0.1868	0.2354	DITM
		0.0076	0.0121	0.0229	Stdev of Spread Effect		0.0243	0.0110	0.0184	
		-2.70	-2.84	-2.23	Mean/Stdev of Spread Effect		7.27	16.93	12.80	
		-5.31	-4.85	-3.92	100*Mean Spread Effect/Mean Pre-Listing Spread		9.07	9.30	11.11	
		14	10	118	N		14	10	118	
		421	682	874	Mean Daily Contract Volume, Pre-Listing		19	25	59	
		29	22	480	Mean Daily Contract Volume, Post-Listing		3.86	0.18	15	
OTM	-0.0055	-0.0169	-0.0342	-0.0679	Mean Spread Effect	-0.0412	0.0037	0.0657	0.1532	ITM
	0.0049	0.0134	0.0172	0.0243	Stdev of Spread Effect	0.0262	0.0392	0.0324	0.0278	
	-1.14	-1.26	-1.99	-2.80	Mean/Stdev of Spread Effect	-1.57	0.09	2.03	5.50	
	-1.83	-2.56	-2.44	-3.42	100*Mean Spread Effect/Mean Pre-Listing Spread	-2.19	0.19	3.37	7.33	
	51	962	359	631	N	51	962	359	631	
	1,146	8,301	2,028	832	Mean Daily Contract Volume, Pre-Listing	65	505	131	231	
	567	8,861	1,964	1,515	Mean Daily Contract Volume, Post-Listing	10	607	180	220	
ATM	0.0314	-0.0009	-0.0329	-0.0775	Mean Spread Effect	-0.1026	-0.0701	0.0054	0.0980	ATM
	0.0296	0.0282	0.0221	0.0261	Stdev of Spread Effect	0.0500	0.0382	0.0317	0.0279	
	1.06	-0.03	-1.49	-2.97	Mean/Stdev of Spread Effect	-2.05	-1.84	0.17	3.51	
	2.87	-0.06	-1.73	-3.74	100*Mean Spread Effect/Mean Pre-Listing Spread	-8.74	-4.48	0.29	4.73	
	314	1,943	502	640	N	314	1,943	502	640	
	4,279	15,895	3,003	1,110	Mean Daily Contract Volume, Pre-Listing	4,597	17,831	3,651	1,594	
	5,216	21,186	4,095	1,711	Mean Daily Contract Volume, Post-Listing	5,528	27,087	5,693	3,103	
ITM	0.0527	-0.0064	-0.0668	-0.1167	Mean Spread Effect	-0.0071	-0.0055	0.0190	0.0763	OTM
	0.0454	0.0361	0.0219	0.0223	Stdev of Spread Effect	0.0290	0.0330	0.0225	0.0230	
	1.16	-0.18	-3.05	-5.23	Mean/Stdev of Spread Effect	-0.25	-0.17	0.85	3.32	
	2.79	-0.33	-3.43	-5.57	100*Mean Spread Effect/Mean Pre-Listing Spread	-1.70	-0.61	1.13	3.76	
	206	1,252	376	614	N	206	1,252	376	614	
	258	1,546	177	138	Mean Daily Contract Volume, Pre-Listing	2,805	12,762	2,693	1,214	
	113	1,178	175	179	Mean Daily Contract Volume, Post-Listing	2,659	20,064	3,683	2,354	
DITM	0.0807	-0.0135	-0.0794	-0.1332	Mean Spread Effect	0.0026	0.0414	0.0633	0.0957	DOTM
	0.0380	0.0433	0.0266	0.0200	Stdev of Spread Effect	0.0154	0.0446	0.0338	0.0272	
	2.12	-0.31	-2.99	-6.64	Mean/Stdev of Spread Effect	0.17	0.93	1.87	3.52	
	4.19	-0.69	-3.99	-6.29	100*Mean Spread Effect/Mean Pre-Listing Spread	1.06	7.50	5.48	5.14	
	76	1,158	882	1,351	N	76	1,158	882	1,351	
	26	447	108	118	Mean Daily Contract Volume, Pre-Listing	873	13,721	3,672	2,330	
	1.40	198	44	55	Mean Daily Contract Volume, Post-Listing	726	14,705	4,375	4,164	

Figure 1. Implied Volatility Structure of S&P 500 Index Call Options: Pre-Listing and Post-Listing of Spider Options. In this figure, a volatility smile curve is generated based on the mean implied volatilities of the call option buckets in our screened sample. The implied volatilities are the mid-quote Black-Scholes-Merton implied volatilities from the OptionMetrics database of Wharton Research Data Services. The mean pre-listing and post-listing implied volatilities of SPX call options are plotted against the five strike price ranges, separately for each of the four maturity classes. To evaluate the effect of Spider options, we then compare the pre-listing and post-listing smiles. There are 257 trading days in the pre-listing period (January 01, 2004 to January 09, 2005) and 120 trading days in the post-listing period (January 10, 2005 to June 30, 2005).

Strike Price Range is defined as the range for the ratio of the closing S&P 500 Index level (S) to the Strike Price (K) and time to maturity (T) is measured in terms of calendar days between the date of trading and the option expiration date. In line with prior research, strike price ranges are defined as follows: Low Strike or Range 1 (deep in the money (DITM) call, $S/K \geq 1.075$), Range 2 (in the money (ITM) call, $1.025 < S/K \leq 1.075$), Range 3 (at the money (ATM) call, $0.975 < S/K \leq 1.025$), Range 4 (out of the money (OTM) call, $0.925 < S/K \leq 0.975$), and High Strike or Range 5 (deep out of the money (DOTM) call, $S/K \leq 0.925$),. Maturity buckets are determined in the following manner: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).

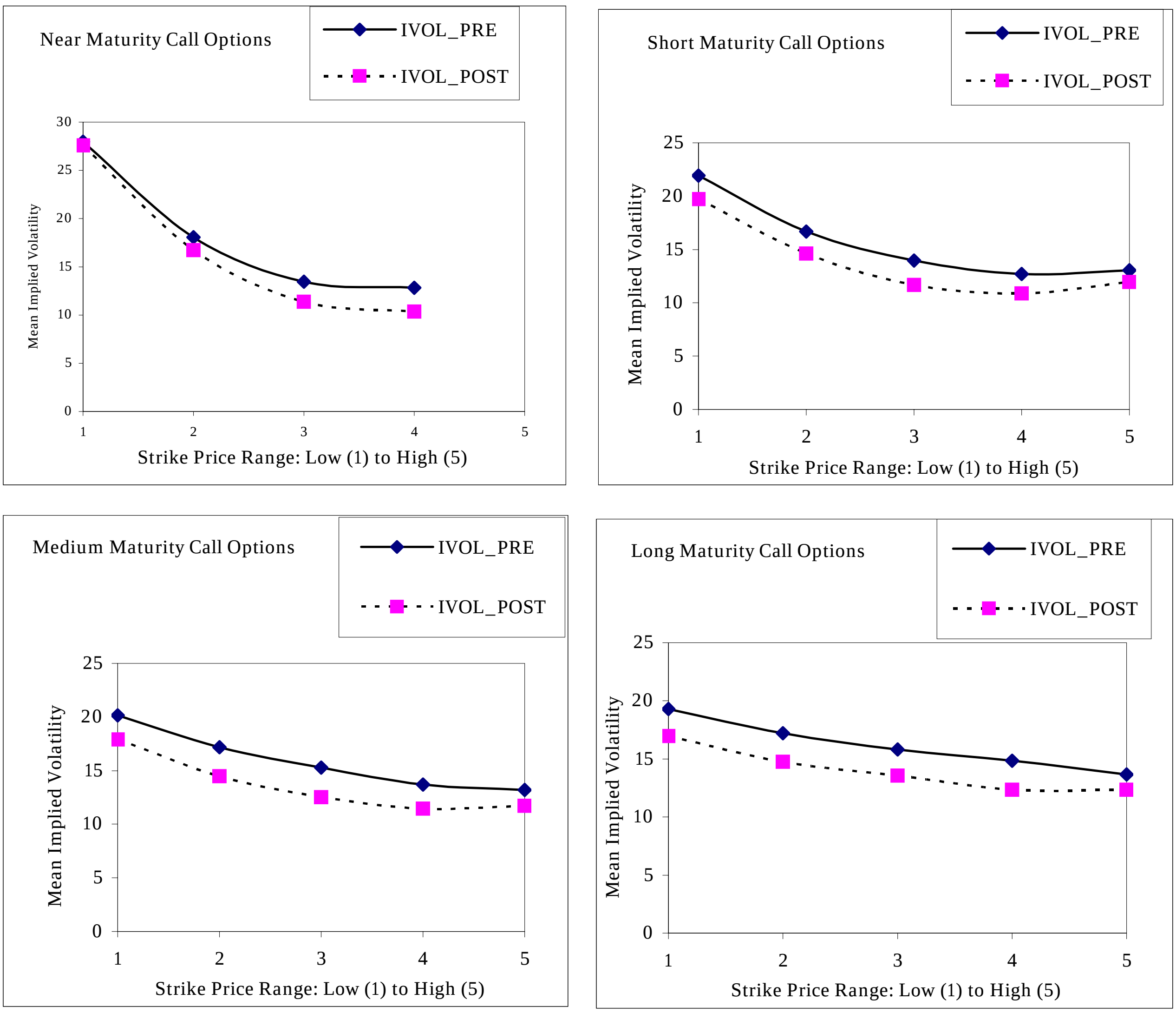


Figure 2. Fitted Call Implied Volatility Smiles: Pre-Listing and Post-Listing of Spider Options. This figure contains the implied volatility smiles of S&P 500 Index call options for alternative maturities. First, Equation (3) was estimated daily using the call option observations: $\ln(V_{i,t}) = \beta_{0,t} + \beta_{1,t} \ln(S_t/K_i) + \beta_{2,t} \ln(T_i)$, where S_t is the S&P 500 Index closing value on day t, option i has a strike of K_i and time to maturity T_i as of day t, and $V_{i,t}$ is the mid-quote Black-Scholes-Merton implied volatility of option i on day t. Second, the mean parameter values were calculated separately for the pre-listing period (January 01, 2004 to January 09, 2005) and the post-listing period (January 10, 2005 to June 30, 2005). Third, inserting a given maturity and the pre-listing mean parameter values in Equation 5, varying S/K over a chosen range of values (from 0.60 to 1.40, in increments of 0.025), and lastly taking exponential of the predicted $\ln(V_{i,})$ values, the pre-listing implied volatility smile (IVOL_PRE) was generated for the given maturity. The post-listing implied volatility smile (IVOL_POST) for the same maturity was generated the same way except now using the post-listing mean parameter values. All data used are from the OptionMetrics Database of the Wharton Research Data Services.

Parameters:	$\beta_{0,t}$	$\beta_{1,t}$	$\beta_{2,t}$
Pre-Listing Mean	2.5882	2.1229	0.0292
Post-Listing Mean	2.4477	2.5952	0.0178

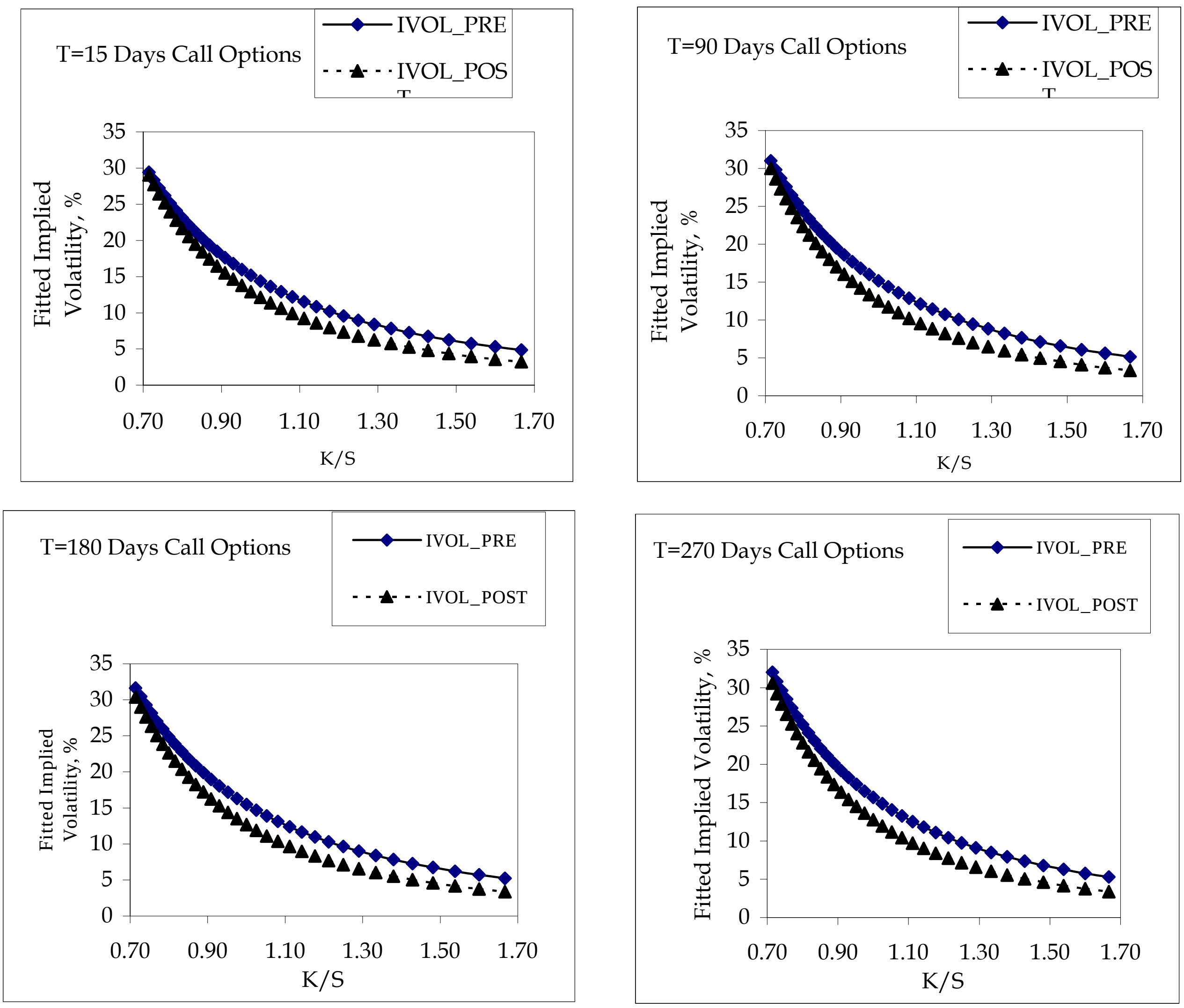
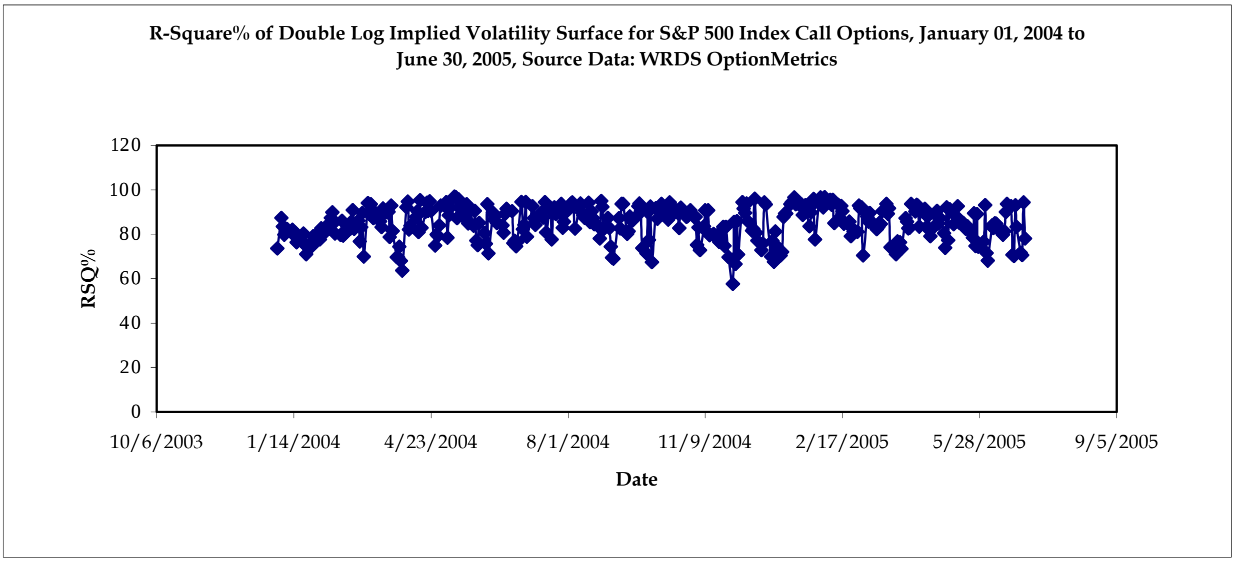
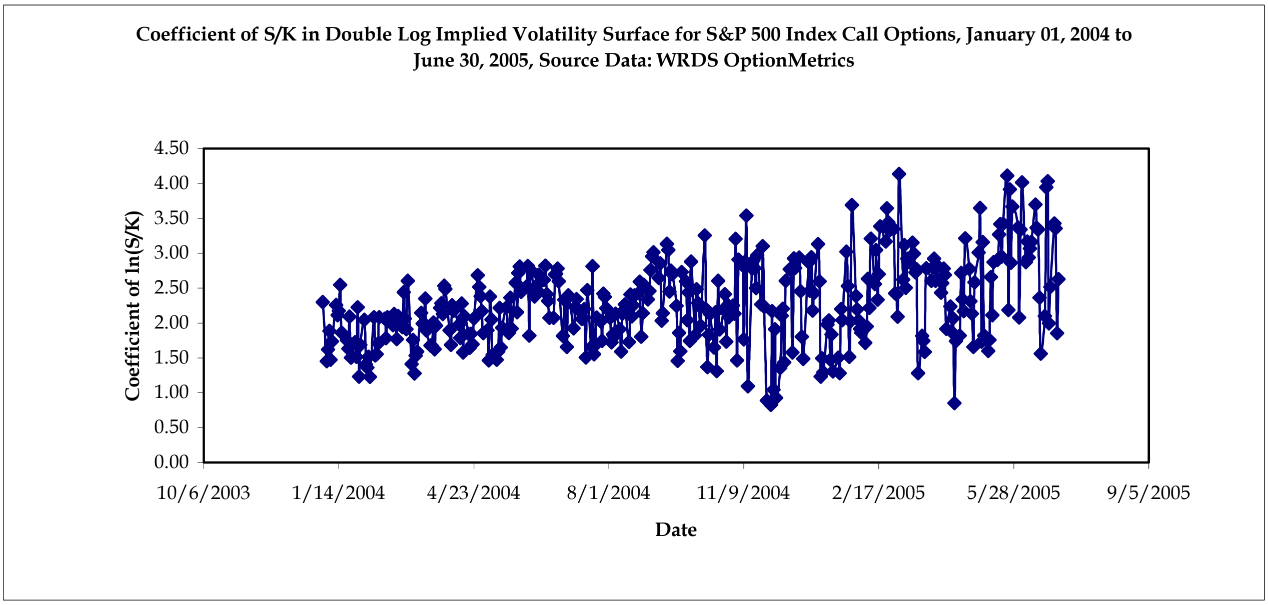


Figure 3. R-Square and Coefficient of ln(S/K) from the Fitted Call Implied Volatility Surfaces. This figure contains the time series of R-Square (RSQ%) and the parameter $\beta_{1,t}$ from Equation (3) estimated daily using the call option observations: $\ln (V_{i,t}) = \beta_{0,t} + \beta_{1,t} \ln (S_t/K_i) + \beta_{2,t} \ln (T_i)$, where S_t is the S&P 500 Index closing value on day t, option i has a strike of K_i and time to maturity T_i as of day t, and $V_{i,t}$ is the mid-quote Black-Scholes-Merton implied volatility of option i on day t. The time series spans January 02, 2004 to June 30, 2005. All data used are from the OptionMetrics Database of the Wharton Research Data Services.





Appendix A. Correlation of Regressors in Equation (1) for Spread Regression

Equation (1): $\ln(Spread_{i,t}) = \beta_0 + \beta_1 \ln(Contract\ Volume_{i,t}) + \beta_2 \ln(Option\ Premium_{i,t}) + \beta_3 \ln(Option\ Volatility_{i,t}) + \beta_4 \ln(Option\ Gamma_{i,t}) + \beta_5\ Money\ Bucket_{i,t}$.

S&P 500 Call Options Spread Regressors, January 01, 2004 to June 30, 2005, Source Data: OptionMetrics, WRDS					
	ln(volume)	ln(premium)	ln(option volatility)	ln(option gamma)	money bucket
ln(volume)	1.00				
ln(premium)	-0.50	1.00			
ln(option volatility)	-0.38	0.95	1.00		
ln(option gamma)	0.56	-0.44	-0.25	1.00	
money bucket	-0.38	0.83	0.87	-0.38	1.00

S&P 500 Put Options Spread Regressors, January 01, 2004 to June 30, 2005, Source Data: OptionMetrics, WRDS					
	ln(volume)	ln(premium)	ln(option volatility)	ln(option gamma)	money bucket
ln(volume)	1.00				
ln(premium)	-0.47	1.00			
ln(option volatility)	-0.32	0.90	1.00		
ln(option gamma)	0.26	0.17	0.46	1.00	
money bucket	-0.30	0.76	0.80	0.38	1.00

Appendix B. Summary Statistics on the Dollar and Percentage Quoted Bid-Ask Spreads and Contract Volume of S&P 500 Index Call Option Buckets in the Pre-Listing and Post-Listing Periods

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	Mean	Stdev	Min	Max	Variables	Count	Mean	Stdev	Min	Max	in Mean	in Mean	Buckets
Near Maturity	250	0.302	0.156	0.050	0.800	Dollar Spread	51	0.258	0.139	0.050	0.750	(0.04)	(14.62)	Near Maturity
OTM Call	250	32.180	17.598	1.980	100.000	% Spread	51	35.827	21.833	11.111	100.000	3.65	11.33	OTM Call
	250	1,178	1,844	0	12,515	Contract Volume	51	1,333	1,723	19	9,864	155.11	13.16	
Near Maturity	669	1.093	0.627	0.100	2.800	Dollar Spread	314	0.921	0.620	0.100	2.000	(0.17)	(15.80)	Near Maturity
ATM Call	669	9.893	5.660	1.047	41.667	% Spread	314	9.726	6.874	1.042	51.163	(0.17)	(1.69)	ATM Call
	669	1,644	2,425	0	17,692	Contract Volume	314	1,994	2,839	0	22,179	349.70	21.27	
Near Maturity	430	1.890	0.469	0.500	2.800	Dollar Spread	206	1.650	0.630	0.500	2.000	(0.24)	(12.73)	Near Maturity
ITM Call	430	3.829	1.385	0.629	7.587	% Spread	206	3.334	1.608	0.590	6.410	(0.50)	(12.94)	ITM Call
	430	154	653	0	10,097	Contract Volume	206	66	326	0	4,010	(88.24)	(57.31)	
Near Maturity	184	1.928	0.562	0.500	3.000	Dollar Spread	76	1.653	0.631	0.500	2.000	(0.28)	(14.27)	Near Maturity
DITM Call	184	1.870	0.601	0.324	3.487	% Spread	76	1.575	0.668	0.299	2.384	(0.30)	(15.79)	DITM Call
	184	35.636	143.495	0	1,050	Contract Volume	76	2.211	6.973	0	42	(33.43)	(93.80)	
Short Maturity	336	0.387	0.179	0.050	1.400	Dollar Spread	14	0.289	0.142	0.050	0.500	(0.10)	(25.32)	Short Maturity
DOTM Call	336	43.738	23.021	5.556	104.762	% Spread	14	55.186	21.486	6.452	90.909	11.45	26.17	DOTM Call
	336	322	885	0	10,174	Contract Volume	14	249	471	0	1,660	(72.44)	(22.51)	
Short Maturity	2,477	0.660	0.375	0.050	3.200	Dollar Spread	962	0.665	0.333	0.050	1.600	0.01	0.87	Short Maturity
OTM Call	2,477	20.021	13.246	1.163	100.000	% Spread	962	23.231	16.370	1.460	100.000	3.21	16.04	OTM Call
	2,477	861	1,472	0	23,666	Contract Volume	962	1,105	3,139	0	58,416	244.03	28.33	
Short Maturity	3,511	1.516	0.576	0.100	4.000	Dollar Spread	1,943	1.428	0.534	0.100	2.800	(0.09)	(5.83)	Short Maturity
ATM Call	3,511	7.765	3.306	0.385	26.087	% Spread	1,943	8.520	3.906	0.627	32.653	0.75	9.72	ATM Call
	3,511	1163	2166	0	27326	Contract Volume	1,943	1308	2684	0	27903	144.97	12.46	
Short Maturity	2,404	1.932	0.413	0.200	4.000	Dollar Spread	1,252	1.915	0.344	0.500	4.000	(0.02)	(0.88)	Short Maturity
ITM Call	2,404	3.414	1.080	0.240	8.909	% Spread	1,252	3.338	1.013	0.551	6.452	(0.08)	(2.23)	ITM Call
	2,404	165	759	0	12,259	Contract Volume	1,252	113	503	0	6,168	(52.29)	(31.64)	
Short Maturity	2,793	1.971	0.429	0.100	4.000	Dollar Spread	1,158	1.911	0.361	0.500	2.800	(0.06)	(3.07)	Short Maturity
DITM Call	2,793	1.649	0.510	0.106	4.630	% Spread	1,158	1.549	0.472	0.250	2.627	(0.10)	(6.11)	DITM Call
	2,793	41	307	0	7,740	Contract Volume	1,158	21	148	0	2,234	(20.63)	(50.14)	
Medium Maturity	1,082	0.709	0.294	0.050	2.100	Dollar Spread	10	1.000	0.249	0.600	1.300	0.29	40.99	Medium Maturity
DOTM Call	1,082	26.311	18.809	1.786	133.333	% Spread	10	14.763	3.846	10.072	22.222	(11.55)	(43.89)	DOTM Call
	1,082	162	807	0	16,935	Contract Volume	10	268	332	2	1,003	106.30	65.58	
Medium Maturity	1,416	1.400	0.487	0.100	3.200	Dollar Spread	359	1.335	0.493	0.200	2.400	(0.07)	(4.69)	Medium Maturity
OTM Call	1,416	10.668	4.397	0.496	33.333	% Spread	359	10.990	4.000	1.031	22.951	0.32	3.02	OTM Call
	1,416	368	930	0	12,224	Contract Volume	359	656	1,183	0	7,825	288.36	78.34	
Medium Maturity	1,160	1.903	0.406	0.200	4.000	Dollar Spread	502	1.908	0.421	0.200	2.800	0.00	0.26	Medium Maturity
ATM Call	1,160	5.269	1.835	0.366	14.085	% Spread	502	5.857	2.000	0.864	11.111	0.59	11.15	ATM Call
	1,160	665	1,520	0	15,090	Contract Volume	502	979	1,905	0	16,362	313.62	47.14	
Medium Maturity	1,087	1.951	0.358	0.200	4.000	Dollar Spread	376	2.023	0.462	0.500	2.800	0.07	3.70	Medium Maturity
ITM Call	1,087	2.675	0.674	0.224	6.711	% Spread	376	2.709	0.783	0.479	5.501	0.03	1.26	ITM Call
	1,087	42	235	0	4,765	Contract Volume	376	56	301	0	4,771	14.21	34.05	
Medium Maturity	2,162	1.990	0.416	0.200	4.000	Dollar Spread	882	2.013	0.443	0.500	3.000	0.02	1.17	Medium Maturity
DITM Call	2,162	1.473	0.429	0.102	4.124	% Spread	882	1.344	0.422	0.241	2.794	(0.13)	(8.74)	DITM Call
	2,162	13	88	0	2,202	Contract Volume	882	6	50	0	1,000	(6.89)	(53.50)	
Long Maturity	1,919	1.301	0.589	0.200	4.000	Dollar Spread	118	1.853	0.429	0.500	3.000	0.55	42.37	Long Maturity
DOTM Call	1,919	14.746	9.945	0.775	107.692	% Spread	118	9.184	2.205	1.919	14.679	(5.56)	(37.72)	DOTM Call
	1,919	117	529	0	11,011	Contract Volume	118	488	1,572	0	14,350	371.24	317.34	
Long Maturity	1,676	1.989	0.492	0.200	4.000	Dollar Spread	631	1.926	0.517	0.200	3.000	(0.06)	(3.16)	Long Maturity
OTM Call	1,676	6.204	2.138	0.364	16.393	% Spread	631	6.622	2.355	0.866	15.152	0.42	6.74	OTM Call
	1,676	128	399	0	5,050	Contract Volume	631	288	757	0	6,800	160.52	125.76	
Long Maturity	1,406	2.071	0.498	0.200	4.000	Dollar Spread	640	2.056	0.445	0.500	3.000	(0.01)	(0.72)	Long Maturity
ATM Call	1,406	3.532	1.013	0.243	8.949	% Spread	640	3.482	1.022	0.576	6.390	(0.05)	(1.41)	ATM Call
	1,406	203	516	0	7,126	Contract Volume	640	321	731	0	7,280	117.92	58.12	
Long Maturity	1,148	2.095	0.521	0.200	4.000	Dollar Spread	614	2.037	0.438	0.500	3.000	(0.06)	(2.78)	Long Maturity
ITM Call	1,148	2.213	0.583	0.159	5.472	% Spread	614	2.092	0.509	0.387	3.288	(0.12)	(5.47)	ITM Call
	1,148	31	194	0	3,300	Contract Volume	614	35	173	0	2,600	4.12	13.31	
Long Maturity	2,923	2.117	0.532	0.200	4.000	Dollar Spread	1,351	2.052	0.433	0.500	3.000	(0.06)	(3.07)	Long Maturity
DITM Call	2,923	1.393	0.413	0.090	3.700	% Spread	1,351	1.238	0.346	0.222	2.213	(0.16)	(11.17)	DITM Call
	2,923	10	154	0	7,450	Contract Volume	1,351	5	38	0	750	(5.53)	(53.24)	

This appendix reports summary statistics for the dollar bid-ask spread and the percentage bid-ask spread (=100*dollar bid-ask spread/mid-quote) of the S&P 500 Index call options by option buckets. The bid and ask quotes are the daily closing best bid and best ask quotes from the OptionMetrics database of the Wharton research Data Services. Contract volume is the total number of contracts traded during the day. The pre-listing period is January 01, 2004 to January 09, 2005, and the post-listing period is January 30, 2005. Spider options started trading on January 10, 2005. Strike buckets are: deep in the money (DITM) call, $S/K \geq 1.075$, in the money (ITM) call, $1.025 < S/K \leq 1.075$, at the money (ATM) call, $0.975 < S/K \leq 1.025$, out of the money (OTM) call, $0.925 < S/K \leq 0.975$, and deep out of the money (DOTM) call, $S/K \leq 0.925$. Maturity buckets in terms of days are: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).

Appendix C. Summary Statistics on the Dollar and Percentage Quoted Bid-Ask Spreads and Contract Volume of S&P 500 Index Put Option Buckets

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	**Mean**	Stdev	Min	Max	**Variables**	Count	**Mean**	Stdev	Min	Max	**in Mean**	in Mean	**Buckets**
Near Maturity	184	**0.245**	0.140	0.050	0.700	Dollar Spread	76	**0.233**	0.111	0.050	0.500	**(0.01)**	(4.98)	Near Maturity
DOTM Put	184	**40.643**	21.312	4.444	94.737	% Spread	76	**45.061**	16.743	9.524	94.737	**4.42**	10.87	DOTM Put
	184	**1,219**	1,925	0	14,988	Contract Volume	76	**1,146**	3,301	0	26,927	**(72.85)**	(5.98)	
Near Maturity	430	**0.420**	0.223	0.050	1.000	Dollar Spread	206	**0.356**	0.199	0.050	0.800	**(0.06)**	(15.13)	Near Maturity
OTM Put	430	**21.771**	13.940	1.770	116.667	% Spread	206	**25.597**	14.552	2.532	90.909	**3.83**	17.57	OTM Put
	430	**1,677**	2,256	0	16,223	Contract Volume	206	**1,549**	1,836	0	10,292	**(127.69)**	(7.62)	
Near Maturity	669	**1.174**	0.612	0.100	2.800	Dollar Spread	314	**0.962**	0.604	0.050	2.000	**(0.21)**	(18.04)	Near Maturity
ATM Put	669	**9.006**	4.209	0.913	25.000	% Spread	314	**8.733**	5.211	1.036	33.333	**(0.27)**	(3.03)	ATM Put
	669	**1,766**	2,361	0	13,336	Contract Volume	314	**2,112**	2,633	0	13,159	**346.49**	19.62	
Near Maturity	250	**1.882**	0.453	0.500	2.800	Dollar Spread	51	**1.700**	0.599	0.500	2.000	**(0.18)**	(9.65)	Near Maturity
ITM Put	250	**4.272**	1.391	0.815	8.333	% Spread	51	**4.319**	1.636	1.015	6.211	**0.05**	1.10	ITM Put
	250	**66.700**	213.163	0	1,830	Contract Volume	51	**23.098**	42.859	0	201	**(43.60)**	(65.37)	
Short Maturity	2,793	**0.552**	0.299	0.050	2.600	Dollar Spread	1,158	**0.474**	0.227	0.050	1.200	**(0.08)**	(14.16)	Short Maturity
DOTM Put	2,793	**24.293**	15.482	1.550	107.692	% Spread	1,158	**30.280**	17.067	2.353	100.000	**5.99**	24.64	DOTM Put
	2,793	**1,263**	3,946	0	74,098	Contract Volume	1,158	**1,524**	4,542	0	58,015	**261.21**	20.69	
Short Maturity	2,404	**0.897**	0.463	0.050	3.200	Dollar Spread	1,252	**0.730**	0.334	0.050	1.600	**(0.17)**	(18.57)	Short Maturity
OTM Put	2,404	**13.526**	6.624	1.036	57.143	% Spread	1,252	**16.483**	8.112	1.136	62.069	**2.96**	21.86	OTM Put
	2,404	**1,364**	2,315	0	61,303	Contract Volume	1,252	**1,923**	4,000	0	57,382	**558.81**	40.96	
Short Maturity	3,511	**1.564**	0.554	0.100	4.000	Dollar Spread	1,943	**1.480**	0.514	0.100	2.000	**(0.08)**	(5.40)	Short Maturity
ATM Put	3,511	**7.528**	2.932	0.593	21.583	% Spread	1,943	**7.991**	3.095	1.000	26.667	**0.46**	6.15	ATM Put
	3,511	**1305**	2285	0	23995	Contract Volume	1,943	**1673**	3194	0	31447	**367.72**	28.17	
Short Maturity	2,477	**1.935**	0.422	0.100	5.000	Dollar Spread	962	**1.926**	0.317	0.500	2.800	**(0.01)**	(0.47)	Short Maturity
ITM Put	2,477	**3.560**	1.206	0.226	10.526	% Spread	962	**3.870**	1.084	0.709	6.250	**0.31**	8.69	ITM Put
	2,477	**52**	248	0	4,772	Contract Volume	962	**76**	431	0	8,252	**23.36**	44.62	
Short Maturity	336	**1.949**	0.531	0.500	4.000	Dollar Spread	14	**2.000**	0.000	2.000	2.000	**0.05**	2.64	Short Maturity
DITM Put	336	**1.808**	0.508	0.346	4.162	% Spread	14	**1.907**	0.126	1.718	2.119	**0.10**	5.50	DITM Put
	336	**15**	122	0	2,100	Contract Volume	14	**33**	87	0	330	**18.55**	127.70	
Medium Maturity	2,162	**1.154**	0.458	0.100	3.200	Dollar Spread	882	**0.932**	0.416	0.100	2.000	**(0.22)**	(19.19)	Medium Maturity
DOTM Put	2,162	**12.545**	5.142	1.058	38.462	% Spread	882	**18.132**	8.370	1.242	72.727	**5.59**	44.54	DOTM Put
	2,162	**436**	1,131	0	13,692	Contract Volume	882	**595**	2,216	0	48,241	**158.79**	36.38	
Medium Maturity	1,087	**1.685**	0.437	0.200	3.300	Dollar Spread	376	**1.455**	0.454	0.200	2.400	**(0.23)**	(13.62)	Medium Maturity
OTM Put	1,087	**7.950**	2.634	0.692	17.544	% Spread	376	**9.887**	3.297	1.047	21.875	**1.94**	24.37	OTM Put
	1,087	**637**	1,154	0	10,787	Contract Volume	376	**1,176**	1,704	0	9,082	**538.88**	84.64	
Medium Maturity	1,160	**1.873**	0.426	0.200	4.000	Dollar Spread	502	**1.799**	0.434	0.200	2.800	**(0.07)**	(3.95)	Medium Maturity
ATM Put	1,160	**4.959**	1.641	0.420	11.834	% Spread	502	**5.984**	1.896	0.797	10.884	**1.02**	20.67	ATM Put
	1,160	**809**	1,716	0	17,827	Contract Volume	502	**1,361**	2,340	0	18,335	**552.07**	68.25	
Medium Maturity	1,416	**1.951**	0.355	0.200	4.000	Dollar Spread	359	**1.975**	0.430	0.500	2.800	**0.02**	1.26	Medium Maturity
ITM Put	1,416	**2.716**	0.731	0.214	6.061	% Spread	359	**3.275**	1.028	0.528	6.863	**0.56**	20.59	ITM Put
	1,416	**24**	150	0	3,458	Contract Volume	359	**60**	431	0	7,534	**36.46**	153.12	
Medium Maturity	1,082	**2.008**	0.445	0.200	4.000	Dollar Spread	10	**2.000**	0.000	2.000	2.000	**(0.01)**	(0.42)	Medium Maturity
DITM Put	1,082	**1.565**	0.453	0.163	3.876	% Spread	10	**1.891**	0.096	1.733	2.016	**0.33**	20.88	DITM Put
	1,082	**6**	43	0	500	Contract Volume	10	**2**	3	0	10	**(3.73)**	(62.88)	
Long Maturity	2,923	**1.860**	0.525	0.200	4.000	Dollar Spread	1,351	**1.564**	0.504	0.200	3.000	**(0.30)**	(15.91)	Long Maturity
DOTM Put	2,923	**8.303**	3.016	0.585	22.535	% Spread	1,351	**11.217**	3.911	1.000	21.488	**2.91**	35.10	DOTM Put
	2,923	**205**	714	0	14,065	Contract Volume	1,351	**370**	1,442	0	36,400	**164.97**	80.53	
Long Maturity	1,148	**2.031**	0.507	0.200	4.000	Dollar Spread	614	**1.948**	0.463	0.200	3.000	**(0.08)**	(4.08)	Long Maturity
OTM Put	1,148	**5.147**	1.552	0.419	11.086	% Spread	614	**6.673**	1.816	1.020	10.256	**1.53**	29.66	OTM Put
	1,148	**272**	725	0	9,000	Contract Volume	614	**460**	1,373	0	24,725	**188.34**	69.33	
Long Maturity	1,406	**2.071**	0.504	0.200	4.000	Dollar Spread	640	**2.019**	0.468	0.300	3.000	**(0.05)**	(2.51)	Long Maturity
ATM Put	1,406	**3.402**	0.946	0.303	8.147	% Spread	640	**4.302**	1.153	0.758	7.326	**0.90**	26.47	ATM Put
	1,406	**291**	752	0	9,670	Contract Volume	640	**582**	1,160	0	11,654	**290.47**	99.72	
Long Maturity	1,676	**2.090**	0.522	0.200	4.000	Dollar Spread	631	**2.048**	0.472	0.500	3.000	**(0.04)**	(2.03)	Long Maturity
ITM Put	1,676	**2.347**	0.624	0.190	4.994	% Spread	631	**2.668**	0.722	0.478	4.682	**0.32**	13.67	ITM Put
	1,676	**35**	228	0	5,568	Contract Volume	631	**42**	255	0	3,089	**6.30**	17.76	
Long Maturity	1,919	**2.120**	0.534	0.200	4.000	Dollar Spread	118	**2.181**	0.353	0.500	3.000	**0.06**	2.91	Long Maturity
DITM Put	1,919	**1.375**	0.457	0.144	3.515	% Spread	118	**1.994**	0.358	0.414	2.967	**0.62**	45.00	DITM Put
	1,919	**8**	85	0	2,500	Contract Volume	118	**15**	74	0	530	**6.93**	88.17	

This appendix reports summary statistics for the dollar bid-ask spread and the percentage bid-ask spread (=100*dollar bid-ask spread/mid-quote) of the S&P 500 Index put options by option buckets. The bid and ask quotes are the daily closing best bid and best ask quotes from the OptionMetrics database of the Wharton research Data Services. Contract volume is the total number of contracts traded during the day. The pre-listing period is January 01, 2004 to January 09, 2005, and the post-listing period is January 30, 2005. Spider options started trading on January 10, 2005. Strike buckets are: deep in the money (DOTM) put, $S/K \geq 1.075$, out of the money (OTM) put, $1.025 < S/K \leq 1.075$, at the money (ATM) put, $0.975 < S/K \leq 1.025$, in the money (ITM) put, $0.925 < S/K \leq 0.975$, and deep in the money (DITM) put, $S/K \leq 0.925$. Maturity buckets in terms of days are: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).

Appendix D. Summary Statistics on the Moneyness (S/X), Time to Maturity, Implied Volatility of S&P 500 Index Call Option Buckets

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	**Mean**	Stdev	Min	Max	**Variables**	Count	**Mean**	Stdev	Min	Max	**in Mean**	in Mean	**Buckets**
Near Maturity	250	**0.963**	0.009	0.934	0.975	Index/Strike	51	**0.968**	0.004	0.959	0.975	**0.01**	0.59	Near Maturity
OTM Call	250	**17.240**	1.353	15.000	19.000	Maturity	51	**17.451**	1.270	15.000	19.000	**0.21**	1.22	OTM Call
	250	**12.842**	1.277	9.946	16.105	IVOL	51	**10.358**	0.864	8.740	12.052	**(2.48)**	(19.34)	
	250	**1.139**	0.689	0.275	3.800	Premium	51	**0.844**	0.457	0.275	2.175	**(0.29)**	(25.91)	
Near Maturity	669	**1.000**	0.014	0.975	1.025	Index/Strike	314	**0.999**	0.014	0.975	1.025	**(0.00)**	(0.01)	Near Maturity
ATM Call	669	**16.936**	1.408	15.000	19.000	Maturity	314	**17.000**	1.347	15.000	19.000	**0.06**	0.38	ATM Call
	669	**13.448**	1.862	9.566	20.527	IVOL	314	**11.383**	1.811	8.267	18.541	**(2.06)**	(15.35)	
	669	**13.592**	8.849	1.400	34.700	Premium	314	**12.765**	9.301	0.800	34.300	**(0.83)**	(6.08)	
Near Maturity	430	**1.047**	0.014	1.025	1.075	Index/Strike	206	**1.045**	0.014	1.025	1.075	**(0.00)**	(0.14)	Near Maturity
ITM Call	430	**17.009**	1.411	15.000	19.000	Maturity	206	**17.102**	1.395	15.000	19.000	**0.09**	0.54	ITM Call
	430	**18.054**	3.791	7.810	29.742	IVOL	206	**16.713**	4.407	7.418	28.223	**(1.34)**	(7.43)	
	430	**52.735**	13.636	30.500	86.100	Premium	206	**53.773**	14.651	31.200	84.750	**1.04**	1.97	
Near Maturity	184	**1.103**	0.021	1.075	1.167	Index/Strike	76	**1.099**	0.018	1.075	1.162	**(0.00)**	(0.29)	Near Maturity
DITM Call	184	**17.130**	1.476	15.000	19.000	Maturity	76	**17.382**	1.514	15.000	19.000	**0.25**	1.47	DITM Call
	184	**27.978**	5.805	16.203	49.493	IVOL	76	**27.581**	5.705	17.963	40.732	**(0.40)**	(1.42)	
	184	**105.614**	18.516	79.500	160.200	Premium	76	**108.630**	17.411	83.900	167.350	**3.02**	2.86	
Short Maturity	336	**0.913**	0.009	0.878	0.925	Index/Strike	14	**0.917**	0.004	0.911	0.924	**0.00**	0.50	Short Maturity
DOTM Call	336	**61.324**	12.946	26.000	80.000	Maturity	14	**52.714**	13.809	33.000	80.000	**(8.61)**	(14.04)	DOTM Call
	336	**13.046**	1.240	10.656	17.384	IVOL	14	**11.958**	1.330	10.238	14.391	**(1.09)**	(8.34)	
	336	**1.086**	0.716	0.275	4.700	Premium	14	**0.545**	0.203	0.375	1.100	**(0.54)**	(49.86)	
Short Maturity	2,477	**0.955**	0.014	0.925	0.975	Index/Strike	962	**0.960**	0.011	0.925	0.975	**0.00**	0.48	Short Maturity
OTM Call	2,477	**47.225**	16.799	22.000	80.000	Maturity	962	**47.905**	16.159	22.000	80.000	**0.68**	1.44	OTM Call
	2,477	**12.705**	1.375	9.316	18.081	IVOL	962	**10.878**	1.157	8.194	14.364	**(1.83)**	(14.38)	
	2,477	**4.536**	3.412	0.300	18.900	Premium	962	**4.107**	3.010	0.275	16.100	**(0.43)**	(9.45)	
Short Maturity	3,511	**1.000**	0.014	0.975	1.025	Index/Strike	1,943	**0.998**	0.014	0.975	1.025	**(0.00)**	(0.15)	Short Maturity
ATM Call	3,511	**44.645**	16.594	22.000	80.000	Maturity	1,943	**45.560**	16.439	22.000	80.000	**0.92**	2.05	ATM Call
	3,511	**13.975**	1.763	9.386	21.769	IVOL	1,943	**11.686**	1.467	8.563	17.559	**(2.29)**	(16.38)	
	3,511	**21.913**	9.996	2.675	48.500	Premium	1,943	**19.753**	10.103	1.650	47.000	**(2.16)**	(9.86)	
Short Maturity	2,404	**1.048**	0.014	1.025	1.075	Index/Strike	1,252	**1.048**	0.014	1.025	1.075	**(0.00)**	(0.03)	Short Maturity
ITM Call	2,404	**44.962**	16.926	22.000	80.000	Maturity	1,252	**42.988**	16.023	22.000	80.000	**(1.97)**	(4.39)	ITM Call
	2,404	**16.684**	2.368	7.450	26.280	IVOL	1,252	**14.621**	2.321	8.572	23.887	**(2.06)**	(12.37)	
	2,404	**59.486**	13.218	32.300	89.700	Premium	1,252	**60.714**	14.230	32.400	92.200	**1.23**	2.06	
Short Maturity	2,793	**1.123**	0.033	1.075	1.200	Index/Strike	1,158	**1.122**	0.035	1.075	1.199	**(0.00)**	(0.08)	Short Maturity
DITM Call	2,793	**51.217**	17.321	22.000	80.000	Maturity	1,158	**50.346**	17.052	22.000	80.000	**(0.87)**	(1.70)	DITM Call
	2,793	**21.933**	4.198	10.077	42.650	IVOL	1,158	**19.724**	4.453	7.539	40.673	**(2.21)**	(10.07)	
	2,793	**125.657**	28.972	76.900	202.000	Premium	1,158	**131.063**	32.333	82.600	202.900	**5.41**	4.30	
Medium Maturity	1,082	**0.896**	0.025	0.805	0.925	Index/Strike	10	**0.917**	0.004	0.911	0.923	**0.02**	2.42	Medium Maturity
DOTM Call	1,082	**131.760**	27.383	81.000	180.000	Maturity	10	**156.000**	12.824	142.000	179.000	**24.24**	18.40	DOTM Call
	1,082	**13.183**	1.038	10.841	17.807	IVOL	10	**11.716**	0.743	10.686	12.970	**(1.47)**	(11.13)	
	1,082	**4.062**	2.935	0.350	15.400	Premium	10	**7.020**	1.972	4.000	9.850	**2.96**	72.82	
Medium Maturity	1,416	**0.950**	0.014	0.925	0.975	Index/Strike	359	**0.955**	0.013	0.925	0.975	**0.01**	0.56	Medium Maturity
OTM Call	1,416	**125.573**	30.982	81.000	180.000	Maturity	359	**123.173**	31.692	81.000	180.000	**(2.40)**	(1.91)	OTM Call
	1,416	**13.715**	1.364	10.684	18.149	IVOL	359	**11.450**	1.032	9.138	14.356	**(2.27)**	(16.52)	
	1,416	**15.170**	7.308	1.950	40.800	Premium	359	**13.385**	6.104	2.900	31.600	**(1.78)**	(11.76)	
Medium Maturity	1,160	**0.999**	0.014	0.975	1.025	Index/Strike	502	**0.999**	0.014	0.975	1.025	**(0.00)**	(0.04)	Medium Maturity
ATM Call	1,160	**120.291**	31.653	81.000	180.000	Maturity	502	**116.088**	31.024	81.000	180.000	**(4.20)**	(3.49)	ATM Call
	1,160	**15.297**	1.693	11.554	19.997	IVOL	502	**12.536**	1.148	9.998	15.952	**(2.76)**	(18.05)	
	1,160	**39.072**	11.063	16.200	67.600	Premium	502	**35.769**	12.084	14.400	68.000	**(3.30)**	(8.45)	
Medium Maturity	1,087	**1.049**	0.014	1.025	1.075	Index/Strike	376	**1.050**	0.014	1.025	1.075	**0.00**	0.06	Medium Maturity
ITM Call	1,087	**123.749**	30.178	81.000	180.000	Maturity	376	**123.359**	31.711	81.000	180.000	**(0.39)**	(0.31)	ITM Call
	1,087	**17.195**	1.670	12.471	22.459	IVOL	376	**14.489**	1.228	11.362	18.784	**(2.71)**	(15.74)	
	1,087	**74.938**	12.091	47.400	104.500	Premium	376	**77.055**	13.737	50.400	107.200	**2.12**	2.83	
Medium Maturity	2,162	**1.132**	0.034	1.075	1.200	Index/Strike	882	**1.142**	0.037	1.075	1.200	**0.01**	0.88	Medium Maturity
DITM Call	2,162	**124.533**	31.502	81.000	180.000	Maturity	882	**126.057**	31.037	81.000	180.000	**1.52**	1.22	DITM Call
	2,162	**20.147**	2.335	10.631	29.412	IVOL	882	**17.906**	2.421	12.537	50.636	**(2.24)**	(11.12)	
	2,162	**140.505**	27.681	86.900	210.700	Premium	882	**156.700**	31.822	92.900	213.600	**16.19**	11.53	

Appendix D Continued. Summary Statistics on the Moneyness (S/X), Time to Maturity, Implied Volatility of S&P 500 Index Call Option Buckets

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	**Mean**	Stdev	Min	Max	**Variables**	Count	**Mean**	Stdev	Min	Max	**in Mean**	in Mean	**Buckets**
Long Maturity	1,919	**0.881**	0.032	0.800	0.925	Index/Strike	118	**0.917**	0.006	0.896	0.925	**0.04**	4.06	Long Maturity
DOTM Call	1,919	**274.194**	50.820	183.000	365.000	Maturity	118	**298.941**	43.809	214.000	365.000	**24.75**	9.03	DOTM Call
	1,919	**13.666**	1.000	11.196	17.123	IVOL	118	**12.344**	0.741	10.299	13.932	**(1.32)**	(9.68)	
	1,919	**11.870**	7.323	0.450	35.500	Premium	118	**20.915**	5.105	10.900	31.300	**9.05**	76.21	
Long Maturity	1,676	**0.952**	0.014	0.925	0.975	Index/Strike	631	**0.950**	0.014	0.925	0.975	**(0.00)**	(0.13)	Long Maturity
OTM Call	1,676	**264.362**	50.522	183.000	365.000	Maturity	631	**271.044**	52.330	183.000	365.000	**6.68**	2.53	OTM Call
	1,676	**14.835**	1.327	11.435	18.352	IVOL	631	**12.360**	1.084	9.757	15.080	**(2.47)**	(16.68)	
	1,676	**34.387**	9.452	11.200	61.600	Premium	631	**31.594**	10.635	10.900	59.100	**(2.79)**	(8.12)	
Long Maturity	1,406	**0.998**	0.014	0.975	1.025	Index/Strike	640	**1.000**	0.015	0.975	1.025	**0.00**	0.24	Long Maturity
ATM Call	1,406	**271.809**	50.838	183.000	365.000	Maturity	640	**266.141**	52.482	183.000	365.000	**(5.67)**	(2.09)	ATM Call
	1,406	**15.816**	1.336	12.511	19.617	IVOL	640	**13.572**	1.125	10.629	16.511	**(2.24)**	(14.19)	
	1,406	**60.547**	11.649	34.400	93.500	Premium	640	**61.627**	13.342	31.300	94.700	**1.08**	1.78	
Long Maturity	1,148	**1.050**	0.014	1.025	1.075	Index/Strike	614	**1.050**	0.014	1.025	1.075	**(0.00)**	(0.02)	Long Maturity
ITM Call	1,148	**268.458**	52.734	183.000	365.000	Maturity	614	**267.964**	52.493	183.000	365.000	**(0.49)**	(0.18)	ITM Call
	1,148	**17.212**	1.576	13.530	21.097	IVOL	614	**14.749**	1.099	11.753	18.329	**(2.46)**	(14.31)	
	1,148	**95.925**	12.396	64.900	129.600	Premium	614	**98.934**	13.214	66.000	130.700	**3.01**	3.14	
Long Maturity	2,923	**1.133**	0.035	1.075	1.200	Index/Strike	1,351	**1.141**	0.037	1.075	1.200	**0.01**	0.78	Long Maturity
DITM Call	2,923	**272.737**	52.805	183.000	365.000	Maturity	1,351	**266.493**	51.226	183.000	365.000	**(6.24)**	(2.29)	DITM Call
	2,923	**19.292**	1.795	14.472	30.081	IVOL	1,351	**16.967**	1.470	12.955	32.400	**(2.32)**	(12.05)	
	2,923	**156.039**	26.648	101.700	225.700	Premium	1,351	**171.072**	28.954	107.000	231.600	**15.03**	9.63	

This appendix reports summary statistics for the moneyness (Index S/Strike K), time to maturity (T) in days, daily closing mid-quote Black-Scholes-Merton Implied Volatility % (IVOL), and the daily closing mid-quote price of the S&P 500 Index call options by option buckets. All data are from the OptionMetrics database of the Wharton research Data Services. The pre-listing period is January 01, 2004 to January 09, 2005, and the post-listing period is January 30, 2005. Spider options started trading on January 10, 2005. "Change in Mean" equals Post-Listing Mean – Pre-Listing Mean, and the "% Change in Mean" equals "Change in Mean"/ Pre-Listing Mean. Strike buckets are: deep in the money (DITM) call, $S/K \geq 1.075$, in the money (ITM) call, $1.025 < S/K \leq 1.075$, at the money (ATM) call, $0.975 < S/K \leq 1.025$, out of the money (OTM) call, $0.925 < S/K \leq 0.975$, and deep out of the money (DOTM) call, $S/K \leq 0.925$. Maturity buckets in terms of days are: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).

Appendix E. Summary Statistics on the Moneyness (S/X), Time to Maturity, and Implied Volatility of S&P 500 Index Put Option Buckets

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	**Mean**	Stdev	Min	Max	**Variables**	Count	**Mean**	Stdev	Min	Max	**in Mean**	in Mean	**Buckets**
Near Maturity	184	**1.103**	0.021	1.075	1.167	Index/Strike	76	**1.099**	0.018	1.075	1.162	**(0.00)**	(0.29)	Near Maturity
DOTM Put	184	**17.130**	1.476	15.000	19.000	Maturity	76	**17.382**	1.514	15.000	19.000	**0.25**	1.47	DOTM Put
	184	**25.109**	3.507	18.431	38.444	IVOL	76	**23.472**	2.710	19.230	32.557	**(1.64)**	(6.52)	
	184	**0.639**	0.272	0.275	1.550	Premium	76	**0.522**	0.193	0.275	1.175	**(0.12)**	(18.41)	
Near Maturity	430	**1.047**	0.014	1.025	1.075	Index/Strike	206	**1.045**	0.014	1.025	1.075	**(0.00)**	(0.14)	Near Maturity
OTM Put	430	**17.009**	1.411	15.000	19.000	Maturity	206	**17.102**	1.395	15.000	19.000	**0.09**	0.54	OTM Put
	430	**17.891**	2.287	13.390	25.512	IVOL	206	**15.765**	2.031	11.640	20.946	**(2.13)**	(11.88)	
	430	**2.280**	1.215	0.425	6.100	Premium	206	**1.596**	0.842	0.400	4.800	**(0.68)**	(29.99)	
Near Maturity	669	**1.000**	0.014	0.975	1.025	Index/Strike	314	**0.999**	0.014	0.975	1.025	**(0.00)**	(0.01)	Near Maturity
ATM Put	669	**16.936**	1.408	15.000	19.000	Maturity	314	**17.000**	1.347	15.000	19.000	**0.06**	0.38	ATM Put
	669	**13.809**	2.109	6.395	19.737	IVOL	314	**11.522**	1.452	7.492	15.571	**(2.29)**	(16.56)	
	669	**14.694**	8.109	2.250	34.100	Premium	314	**13.167**	8.342	1.950	32.200	**(1.53)**	(10.39)	
Near Maturity	250	**0.963**	0.009	0.934	0.975	Index/Strike	51	**0.968**	0.004	0.959	0.975	**0.01**	0.59	Near Maturity
ITM Put	250	**17.240**	1.353	15.000	19.000	Maturity	51	**17.451**	1.270	15.000	19.000	**0.21**	1.22	ITM Put
	250	**14.821**	3.467	7.193	24.792	IVOL	51	**12.388**	1.440	8.854	15.861	**(2.43)**	(16.42)	
	250	**46.092**	10.666	30.100	80.100	Premium	51	**40.052**	5.385	32.200	50.800	**(6.04)**	(13.10)	
Short Maturity	2,793	**1.123**	0.033	1.075	1.200	Index/Strike	1,158	**1.122**	0.035	1.075	1.199	**(0.00)**	(0.08)	Short Maturity
DOTM Put	2,793	**51.217**	17.321	22.000	80.000	Maturity	1,158	**50.346**	17.052	22.000	80.000	**(0.87)**	(1.70)	DOTM Put
	2,793	**21.602**	2.811	14.738	32.790	IVOL	1,158	**19.883**	2.848	14.042	31.249	**(1.72)**	(7.96)	
	2,793	**3.027**	2.230	0.275	13.400	Premium	1,158	**1.948**	1.318	0.275	8.500	**(1.08)**	(35.64)	
Short Maturity	2,404	**1.048**	0.014	1.025	1.075	Index/Strike	1,252	**1.048**	0.014	1.025	1.075	**(0.00)**	(0.03)	Short Maturity
OTM Put	2,404	**44.962**	16.926	22.000	80.000	Maturity	1,252	**42.988**	16.023	22.000	80.000	**(1.97)**	(4.39)	OTM Put
	2,404	**16.816**	2.149	11.257	24.943	IVOL	1,252	**14.948**	1.825	11.314	21.496	**(1.87)**	(11.11)	
	2,404	**7.714**	4.514	0.650	23.450	Premium	1,252	**5.386**	3.234	0.650	19.050	**(2.33)**	(30.18)	
Short Maturity	3,511	**1.000**	0.014	0.975	1.025	Index/Strike	1,943	**0.998**	0.014	0.975	1.025	**(0.00)**	(0.15)	Short Maturity
ATM Put	3,511	**44.645**	16.594	22.000	80.000	Maturity	1,943	**45.560**	16.439	22.000	80.000	**0.92**	2.05	ATM Put
	3,511	**14.089**	1.880	8.206	21.288	IVOL	1,943	**11.883**	1.579	6.213	17.839	**(2.21)**	(15.65)	
	3,511	**22.645**	8.979	3.900	48.500	Premium	1,943	**20.544**	8.796	3.000	41.900	**(2.10)**	(9.28)	
Short Maturity	2,477	**0.955**	0.014	0.925	0.975	Index/Strike	962	**0.960**	0.011	0.925	0.975	**0.00**	0.48	Short Maturity
ITM Put	2,477	**47.225**	16.799	22.000	80.000	Maturity	962	**47.905**	16.159	22.000	80.000	**0.68**	1.44	ITM Put
	2,477	**13.244**	2.124	5.773	22.920	IVOL	962	**12.026**	1.973	8.139	20.985	**(1.22)**	(9.20)	
	2,477	**58.019**	15.199	30.700	98.200	Premium	962	**52.582**	13.100	32.000	95.900	**(5.44)**	(9.37)	
Short Maturity	336	**0.913**	0.009	0.878	0.925	Index/Strike	14	**0.917**	0.004	0.911	0.924	**0.00**	0.50	Short Maturity
DITM Put	336	**61.324**	12.946	26.000	80.000	Maturity	14	**52.714**	13.809	33.000	80.000	**(8.61)**	(14.04)	DITM Put
	336	**14.888**	2.607	6.227	23.092	IVOL	14	**16.835**	1.544	13.488	18.844	**1.95**	13.08	
	336	**108.878**	12.525	88.200	160.200	Premium	14	**105.307**	7.034	94.400	116.400	**(3.57)**	(3.28)	
Medium Maturity	2,162	**1.132**	0.034	1.075	1.200	Index/Strike	882	**1.142**	0.037	1.075	1.200	**0.01**	0.88	Medium Maturity
DOTM Put	2,162	**124.533**	31.502	81.000	180.000	Maturity	882	**126.057**	31.037	81.000	180.000	**1.52**	1.22	DOTM Put
	2,162	**20.767**	2.063	15.193	27.710	IVOL	882	**18.430**	1.918	13.462	38.906	**(2.34)**	(11.26)	
	2,162	**10.456**	5.254	1.300	29.900	Premium	882	**6.046**	3.412	1.100	19.700	**(4.41)**	(42.18)	
Medium Maturity	1,087	**1.049**	0.014	1.025	1.075	Index/Strike	376	**1.050**	0.014	1.025	1.075	**0.00**	0.06	Medium Maturity
OTM Put	1,087	**123.749**	30.178	81.000	180.000	Maturity	376	**123.359**	31.711	81.000	180.000	**(0.39)**	(0.31)	OTM Put
	1,087	**17.563**	1.694	13.173	22.442	IVOL	376	**14.715**	1.224	11.754	18.296	**(2.85)**	(16.22)	
	1,087	**22.728**	7.015	7.000	42.900	Premium	376	**15.708**	5.399	5.800	29.200	**(7.02)**	(30.89)	
Medium Maturity	1,160	**0.999**	0.014	0.975	1.025	Index/Strike	502	**0.999**	0.014	0.975	1.025	**(0.00)**	(0.04)	Medium Maturity
ATM Put	1,160	**120.291**	31.653	81.000	180.000	Maturity	502	**116.088**	31.024	81.000	180.000	**(4.20)**	(3.49)	ATM Put
	1,160	**15.576**	1.767	9.960	20.213	IVOL	502	**12.701**	1.247	10.034	16.371	**(2.87)**	(18.46)	
	1,160	**40.005**	9.964	17.100	64.900	Premium	502	**31.748**	8.611	13.900	55.100	**(8.26)**	(20.64)	
Medium Maturity	1,416	**0.950**	0.014	0.925	0.975	Index/Strike	359	**0.955**	0.013	0.925	0.975	**0.01**	0.56	Medium Maturity
ITM Put	1,416	**125.573**	30.982	81.000	180.000	Maturity	359	**123.173**	31.692	81.000	180.000	**(2.40)**	(1.91)	ITM Put
	1,416	**14.173**	1.554	8.135	18.369	IVOL	359	**11.762**	1.194	8.961	15.179	**(2.41)**	(17.02)	
	1,416	**74.463**	13.837	43.900	105.200	Premium	359	**63.130**	13.153	39.800	94.750	**(11.33)**	(15.22)	
Medium Maturity	1,082	**0.896**	0.025	0.805	0.925	Index/Strike	10	**0.917**	0.004	0.911	0.923	**0.02**	2.42	Medium Maturity
DITM Put	1,082	**131.760**	27.383	81.000	180.000	Maturity	10	**156.000**	12.824	142.000	179.000	**24.24**	18.40	DITM Put
	1,082	**14.366**	1.783	7.689	21.566	IVOL	10	**13.162**	0.918	12.058	14.509	**(1.20)**	(8.38)	
	1,082	**134.941**	35.465	91.900	276.500	Premium	10	**105.990**	5.489	99.200	115.400	**(28.95)**	(21.45)	

Appendix E Continued. Summary Statistics on the Moneyness (S/X), Time to Maturity, and Implied Volatility of S&P 500 Index Put Option Buckets

	Pre-Listing of Spider Options						Post-Listing of Spider Options					Change	%Change	
Buckets	Count	**Mean**	Stdev	Min	Max	**Variables**	Count	**Mean**	Stdev	Min	Max	**in Mean**	in Mean	**Buckets**
Long Maturity	2,923	**1.133**	0.035	1.075	1.200	Index/Strike	1,351	**1.141**	0.037	1.075	1.200	**0.01**	0.78	Long Maturity
DOTM Put	2,923	**272.737**	52.805	183.000	365.000	Maturity	1,351	**266.493**	51.226	183.000	365.000	**(6.24)**	(2.29)	DOTM Put
	2,923	**19.886**	1.746	14.340	24.991	IVOL	1,351	**17.680**	1.460	13.437	25.294	**(2.21)**	(11.09)	
	2,923	**24.435**	8.267	5.800	51.000	Premium	1,351	**15.242**	6.057	4.600	34.350	**(9.19)**	(37.62)	
Long Maturity	1,148	**1.050**	0.014	1.025	1.075	Index/Strike	614	**1.050**	0.014	1.025	1.075	**(0.00)**	(0.02)	Long Maturity
OTM Put	1,148	**268.458**	52.734	183.000	365.000	Maturity	614	**267.964**	52.493	183.000	365.000	**(0.49)**	(0.18)	OTM Put
	1,148	**17.655**	1.648	12.707	21.027	IVOL	614	**15.211**	1.153	12.130	18.391	**(2.44)**	(13.84)	
	1,148	**40.919**	8.358	18.900	65.700	Premium	614	**30.321**	7.058	15.600	48.600	**(10.60)**	(25.90)	
Long Maturity	1,406	**0.998**	0.014	0.975	1.025	Index/Strike	640	**1.000**	0.015	0.975	1.025	**0.00**	0.24	Long Maturity
ATM Put	1,406	**271.809**	50.838	183.000	365.000	Maturity	640	**266.141**	52.482	183.000	365.000	**(5.67)**	(2.09)	ATM Put
	1,406	**16.175**	1.449	9.779	19.650	IVOL	640	**13.999**	1.221	10.983	17.082	**(2.18)**	(13.45)	
	1,406	**62.381**	10.612	31.400	90.600	Premium	640	**48.188**	9.052	27.300	72.500	**(14.19)**	(22.75)	
Long Maturity	1,676	**0.952**	0.014	0.925	0.975	Index/Strike	631	**0.950**	0.014	0.925	0.975	**(0.00)**	(0.13)	Long Maturity
ITM Put	1,676	**264.362**	50.522	183.000	365.000	Maturity	631	**271.044**	52.330	183.000	365.000	**6.68**	2.53	ITM Put
	1,676	**15.266**	1.457	5.058	18.420	IVOL	631	**12.810**	1.195	10.093	16.070	**(2.46)**	(16.09)	
	1,676	**90.313**	12.365	55.500	121.000	Premium	631	**78.450**	11.896	53.400	104.700	**(11.86)**	(13.14)	
Long Maturity	1,919	**0.881**	0.032	0.800	0.925	Index/Strike	118	**0.917**	0.006	0.896	0.925	**0.04**	4.06	Long Maturity
DITM Put	1,919	**274.194**	50.820	183.000	365.000	Maturity	118	**298.941**	43.809	214.000	365.000	**24.75**	9.03	DITM Put
	1,919	**14.427**	1.360	4.960	19.520	IVOL	118	**13.053**	0.830	10.925	14.900	**(1.37)**	(9.52)	
	1,919	**163.173**	43.242	100.900	283.600	Premium	118	**110.030**	7.818	98.700	133.600	**(53.14)**	(32.57)	

This appendix reports summary statistics for the moneyness (Index S/Strike K), time to maturity (T) in days, daily closing mid-quote Black-Scholes-Merton Implied Volatility % (IVOL), and the daily closing mid-quote price of the S&P 500 Index put options by option buckets. All data are from the OptionMetrics database of the Wharton research Data Services. The pre-listing period is January 01, 2004 to January 09, 2005, and the post-listing period is January 30, 2005. Spider options started trading on January 10, 2005. "Change in Mean" equals Post-Listing Mean – Pre-Listing Mean, and the "% Change in Mean" equals "Change in Mean"/ Pre-Listing Mean. Strike buckets are: deep in the money (DOTM) put, $S/K \geq 1.075$, out of the money (OTM) put, $1.025 < S/K \leq 1.075$, at the money (ATM) put, $0.975 < S/K \leq 1.025$, in the money (ITM) put, $0.925 < S/K \leq 0.975$, and deep in the money (DITM) put, $S/K \leq 0.925$. Maturity buckets in terms of days are: near maturity ($14 \leq T \leq 20$), short maturity ($20 < T \leq 80$), medium maturity ($80 < T \leq 180$), and long maturity ($180 < T \leq 365$).