The Weekend Effect in Equity Option Returns*

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Abstract

We find that returns on options on individual equities display markedly lower returns over weekends (Friday close to Monday close) relative to any other day of the week. These patterns are observed both in unhedged and delta-hedged positions, indicating that the effect is not the result of a weekend effect in the underlying securities. We find even stronger weekend effects in implied volatilities, but only after an adjustment to quote implied volatilities in terms of trading days rather than calendar days. Our results hold for puts and calls over a wide range of maturities and strike prices, for both equally weighted portfolios and for portfolios weighted by open interest, and also for samples that include only the most liquid options in the market. We find no evidence of a weekly seasonal in bid-ask spreads, trading volume, or open interest that could drive the effect. We also do not find evidence that weekend returns are significantly risker than weekday returns, though the weekend effect does appear stronger when the riskiness of the market portfolio is high. The effect is particularly strong over weekends during which the shortest term options expire, and it is also present to a lesser degree over mid-week holidays. Finally, the effect is stronger when the TED spread is high and past delta-hedged returns are high, which we interpret as providing support for a limits of arbitrage explanation of the weekend effect.

1 Introduction

The weekend effect in the stock market represents one of the earliest and most studied pieces of evidence against the Efficient Market Hypothesis, yet the effect has received little attention in recent literature. The obvious explanation is that the weekend effect seems to have disappeared, at least in equity markets, sometime during the last two decades. Why the effect disappeared, or whether there ever was a weekend effect to begin with, as Sullivan, Timmermann, and White (2001) have questioned, remain open questions.

Although the modern weekend effect literature began with the article of French (1980), evidence on the effect was reported 50 years earlier by Fields (1931). Similar effects have been observed in international equity indexes (e.g. Jaffe and Westerfield (1985)) and in a variety of government bond returns (e.g. Gibbons and Hess (1981), Flannery and Protopapadakis (1988)). The robustness of the finding was short-lived, however, as articles like Connolly (1989) and Chang, Pinegar, and Ravichandran (1993) suggested that the effect started disappearing in the 1970s or 80s. Kamara (1997) showed that the disappearance happened the soonest for the largest firms. Chen and Singal (2003) argued that it is the introduction of options on a firm's stock that led to the elimination of the weekend effect in a specific firm. Since options tended to be introduced first for large capitalization firms, this offers a potential explanation of Kamara's result.

The Chen and Singal (2003) finding deserves further investigation because it implies that the weekend effect may not have disappeared, but merely changed addresses. Their story is actually related to the original intuition of Fields (1931), who conjectured that risk-averse equity investors might want to close out their positions on Friday afternoon and open them back up on Monday morning. Chen and Singal modify this intuition by suggesting that it is the short sellers that are most interested in closing positions before the weekend. Their reasoning is simple – with infinite downside risk, naked short positions require constant monitoring, which becomes difficult if not impossible to perform over the weekend.

Chen and Singal (2003) support their hypothesis with the observation that the weekend effect was most pronounced in stocks with high levels of short interest and the finding that the weekend effect disappeared only for those stocks on which options are traded. Their result is also consistent with the decline in the weekend effect for US Treasuries, for which derivative products are widely used.

The same intuition implies another effect that remains unexplored. If investors are generally averse to hold positions with unbounded risk over the weekend, then speculators who have written call option positions should also attempt to close out these positions. Put option writers, while not exposed to a literally unbounded risk, still face the possiblity of losses that are far in excess of those that likely to occur in an equity position, for example. For this reason we believe that the Chen and Singal (2003) hypothesis has the straightforward implication that we should see a weekend effect in call and put options, with weekend option returns being substantially lower than returns over the rest of the week.

We view this story only as one possible motivation for examining weekday effects in equity option markets. More generally, options represent one of the last unexplored asset classes for assessing the survival of the weekend effect. Knowing whether or not such an effect exists has substantial implications for a number of literatures. Besides providing an additional test of the Chen and Singal (2003) hypothesis, an unambiguous result from the options market would directly address the view of Sullivan, Timmermann, and White (2001) that the weekend effect was most likely the result of data mining.

Finding a weekend effect in option returns might also provide a new direction for the option pricing literature in its search for models capable of explaining upward-sloping term structures and smile-shaped cross sections in Black-Scholes implied volatilities. This literature is divided over the importance of jumps versus stochastic volatilities and the correct risk premia to attribute to each (e.g. Pan (2002), Broadie, Chernov, and Johannes (2007)). A weekend effect in option returns would indicate that risks that are more prevalent or less manageable over the weekend are the ones that require the largest (or most negative) risk premia.

We look for a weekend effect in option returns using simple methods. Using the Optionmetrics dataset over the period from January 1996 to June 2007, we form portfolios of options. Portfolios are formed on the basis of option maturity, moneyness, or both. Puts and calls are in different portfolios. We experiment with a variety of sampling and weighting schemes. In addition, we examine returns separately for each year in our sample period.

The results are clear cut. The weekend effect in individual equity option returns is large and negative. We observe the effect in unhedged returns, but an analysis of delta-hedged returns suggests that little of the effect is due to any weekend effect in the underlying stock returns. All results are highly statistically significant, often with t-statistics exceeding 10. We find similar effects in puts and calls and across almost all maturity and moneyness categories.

After an adjustment to quote implied volatilities in terms of trading time rather than calendar time, we find a weekly seasonal in implied volatilities that is even more significant than that of the option returns. We also examine a measure we refer to as "total volatility", which is simply the Black-Scholes implied volatility of the stock price at expiration, not reported per unit of time. As an option moves closer to expiration, it's total volatility tends to decrease as the length of time before expiration decreases. Over the weekend, total volatility declines over twice as much as any other day of the week, which is inconsistent with the observation, first made by French and Roll (1986) and confirmed in our sample below, that the actual volatility of Friday close to Monday close returns is no greater than the volatility of returns over any other close-to-close interval.

Our results are unaffected when we restrict the sample to the most liquid options and to options on firms that are members of the S&P 100. We do not, however, find substantial evidence of a weekend effect in S&P 500 Index options.

We investigate a number of potential explanations for the effect. One is that our results are due to data mining, a concern articulated by Sullivan, Timmermann, and White (2001). Another is that the margin requirements required to write options are more costly to maintain over the weekend than during the week. We find no evidence that options or the underlying stocks are more risky over the weekend, though a greater aversion to whatever risk there is remains an explanation we have no way of ruling out. Neither do we find evidence that our results can be attributed to the biases that result from measurement errors in prices, as in Blume and Stambaugh (1983). Finally, we find no evidence or weekly patterns in volume or open interest that might suggest other liquidity-based explanations of our results.

Regressions reveal that the effect is about 50% stronger for expiration weekends (weekends that follow the last day of trading for front month contracts). It appears to exist to a lesser extent for mid-week holidays as well, though the evidence for this finding is weaker, possibly because of low incidence of mid-week holidays. In addition, the weekend effect is more negative following periods of positive delta-hedged returns, and also in times when S&P 500 Index volatility and the TED spread are high. Since higher values of all three of these variables should make arbitrage strategies more difficult to implement, we interpret these findings as providing evidence for a limits of arbitrage explanation as to why the effect persists.

The paper is organized as follows. In Section 2 we describe our data, sampling methods, and portfolio construction. Section 3 contains results that document weekly patterns in returns, implied volatilities, and liquidity measures. Section 4 examines the determinants of weekend and weekday returns in a regression setting. Section 5 concludes.

2 Data and methods

Our primary data source is the Ivy DB data set from OptionMetrics. This data set includes all US listed options on equities, indexes, and ETFs. In our paper we generally restrict our attention to individual equity options, though for a few results we examine S&P 500 Index options.

Throughout our analysis, we form portfolios of options on the basis of maturity and/or delta. The delta we use is lagged an extra day, i.e. if we are forming a portfolio at day $t-1$ to hold until day t, then we use the delta that was observed on day $t-2$. We do this so that if there are measurement errors in deltas they are not correlated with the returns on the same assets. We consider five maturity ranges and five delta ranges so that all options in a given portfolio are at least roughly comparable and all portfolios have approximately the same number of options included. Finally, we have separate portfolios for calls and puts.

We compute portfolio returns by taking the equal weighted average of the returns, either hedged or unhedged, of each option in that portfolio. Since our dataset includes bid-ask quotes rather than transaction prices, we compute returns from quote midpoints. Since options have zero net supply, the concept of value weighting must be reinterpreted, and what we call value weighted portfolios are actually weighted by the dollar value of open interest for each option. We usually examine excess returns, where we compute riskless returns using the shortest maturity yield provided in the Ivy DB zero curve file.

We impose a number of filters to try to eliminate a number of sources of noise. We find many large errors on the first day an option is introduced, so we exclude the first observation for each contract. Large return reversals (2000% followed by -95% or vice versa) are also eliminated. Because large quotes are likely to be less informative, we eliminate the day t return on an option if any of the following conditions hold:

- day $t-2$ bid price is less than \$0.50 or 0.1% of the price of the underlying stock
- day $t-2$ bid-ask spread is more than 25% of the midpoint
- day $t-1$ or t bid-ask spread is more than \$5.00 or 200% of the midpoint
- day $t-1$ or t ask price is less than the bid or more than twice the price of the underlying stock

The first two conditions represent filters that are implemented prior to the return interval. These focus our attention away from the least liquid segment of the options market, which tends to be deep out-of-the-money contracts. Note that if the day $t-2$ values that these filters are based on are measured with error, then this error should at least be uncorrelated with the subsequent return from day $t-1$ to t. The last two conditions are included to eliminate a small number of major outliers that we do not catch otherwise. These might be data recording errors or non-competitive quotes posted by a market maker who does not want to trade. We also eliminate quotes in which the bid or ask is set to what appears to be an undocumented missing value code (e.g. 999). Finally, we eliminate observations in which there was a stock split between day $t-1$ and day t. Together, these filters eliminate the largest and most suspicious outliers in our sample. We note, however, that all of our main results are robust to dropping all of these filters.

The implied volatilities in our analysis are provided by Ivy DB (with some adjustments we describe below). They are computed using a binomial tree approach that accounts for dividends. (Because they are equivalent to Black-Scholes values for stocks that pay no dividends, we will refer to the implied volatilities and Greeks as "Black-Scholes" values.) The delta of each option is also computed with the Black-Scholes model using the implied volatility from that same option.

Option returns and excess returns are defined as

$$\frac{C_t - C_{t-1}}{C_{t-1}}$$

and

$$\frac{C_t - C_{t-1}}{C_{t-1}} - \mathrm{ND}_{t-1,t} r_{t-1},$$

respectively, where C_t is the option bid-ask midpoint, r_t is the riskless return per day, and $\mathrm{ND}_{t-1,t}$ is the number of calendar days between date $t-1$ and t. Given that the change in value of a delta-hedged portfolio is

$$C_t - C_{t-1} - \Delta\left(S_t - S_{t-1}\right),$$

we define delta-hedged returns as

$$\frac{C_t - C_{t-1}}{C_{t-1}} - \frac{\Delta S_{t-1}}{C_{t-1}} \frac{S_t - S_{t-1}}{S_{t-1}}$$

and delta-hedged excess returns as

$$\frac{C_t - C_{t-1}}{C_{t-1}} - \mathrm{ND}_{t-1,t} r_{t-1} - \frac{\Delta S_{t-1}}{C_{t-1}} \left(\frac{S_t - S_{t-1}}{S_{t-1}} - \mathrm{ND}_{t-1,t} r_{t-1} \right).$$

We view our use of the Black-Scholes model as relatively benign. Even if the delta we use to compute hedged returns is incorrect, those hedged returns nevertheless represent the returns on a feasible investment strategy (abstracting from transactions costs). Delta hedging, while not perfect, can be expected to remove at least the majority of the option's exposure to the underlying stock. Hull and Suo (2002) claim, in fact, that Black-Scholes works about as well as any other model in this regard. When we examine weekday effects in Black-Scholes implied volatilities, our results may also be slightly skewed by model misspecification. Nevertheless, it is hard to imagine how this form of misspecification could causes systematic patterns across different days of the week.

3 Weekday patterns in option markets

3.1 Main findings

Our main results are presented in Tables 1A and 1B. Table 1A displays average excess returns across different days of the week on portfolios of puts and calls sorted by delta. When we average across all options, both puts and calls, we see an average Monday return of -0.62%, indicating that the average option loses more than half of 1% of its value each weekend. The corresponding t-statistic is -16.8. The average returns for other days of the week are all positive.

In examining portfolios of puts or calls sorted on delta, still in Table 1A, we see similar results. Monday returns are in all cases negative, though their statistical significance is sometimes only marginal. Table 1B shows, however, that we get markedly increased statistical precision and a similar weekend effect when we examine delta-hedged returns. This suggests two conclusions. One is that the weekend effect in option returns is not the result of a weekend effect in the underlying stock. If it was, then delta hedging would eliminate at least the majority of that weekly pattern. Second, delta-hedged returns are substantially less volatile than unhedged returns, so standard errors on average hedged returns are much smaller.[1]

Because we observe the same effect in delta-hedged returns, and because we see that effect much more clearly, our subsequent analysis will be focused on delta-hedged positions. In addition, we feel that looking at delta-hedged returns is also simply more interesting. The literature has already examined weekend effects in stock returns, so if delta hedging at least substantially eliminates the portion of the option return that is due to the underlying stock, then whatever is left over must reflect a much less studied set of factors driving asset market returns.

Table 2 performs the same analysis on delta-hedged returns, only now the portfolios are sorted on the basis of maturity rather than delta. Here we see that the effect is strong for all maturities except the longest. Even the 1-10 day maturity range, which many studies throw out because of expiration-day concerns, displays the weekend effect strongly.

[1]The higher levels of statistical significance for the pooled portfolio of unhedged puts and calls is due to the reduction in variance that comes from the offsetting deltas of puts and calls, which has approximately the same effect as delta hedging.

We assess statistical significance of the differences between weekend and non-weekend returns in Table 3, where we now report results for portfolios sorted on the basis of maturity and delta. The table shows that average returns are lower over weekends for almost all portfolios, and most of these results are statistically significant at very high confidence levels.

Table 4 looks at weekday effects in other variables. "Simple" returns are identical to the returns we examined previously but do not subtract the riskless rate. Nothing we have shown is sensitive to whether simple or excess returns are used.

We then look at four different measures of implied volatility. The first is the "unadjusted" implied volatility that is provided in Ivy DB. This measure of volatility tends to rise as options approach expiration, most likely reflecting a misspecification of the Black-Scholes model. Surprisingly, however, we see that the rise is greatest on Mondays. This appears contradictory – how can implied volatility rise, indicating higher option values, when returns are falling?

The answer is in how Ivy DB computes implied volatilities. In the Black-Scholes formula, every place the volatility parameter σ appears it is multiplied by the square root of the time to expiration. Ivy DB measures the time to expiration in terms of calendar time, so that Monday has three days less time to maturity than the Friday that immediately preceded it. There is nothing incorrect about this approach – quoting in terms of calendar time is just a convention – but the interpretability of this convention is slightly problematic. The reason is that the interval from Friday close to Monday close is about as volatile as any other close-to-close period, as first demonstrated by French and Roll (1986). Hence when the time to maturity declines by three days but only one day of actual volatility actually accrues, implied volatility appears to rise.

We address this in two ways. First, we adjust the implied volatility so that it is quoted in terms of trading days rather than calendar days. Second, we examine "total implied volatility", which is the volatility of the terminal stock price, not reported per unit of time. This is computed simply by taking the product of the unadjusted implied volatility and the square root of the time to expiration, measured in calendar time.

With both of these modifications, we see changes in implied volatility that are lower on Mondays than they are for the rest of the week. All the averages we report for these variables are highly statistically significant.

3.2 Robustness

We now ask whether these results are due to changes in our empirical approach. Tables 5A and 5B replicate 1A and 1B but, instead of equal weighting, weight options by the dollar value of their open interest. Statistical significance declines somewhat, but the results are essentially unchanged, at least for the delta-hedged returns.

Table 6 alters the sample selection approach in several different ways. First, to address the potential concern that our data set contains mostly illiquid options, we restrict the sample to include only options on firms that are members of the S&P 100. The results for these firms, both in terms of delta-hedged returns and implied volatilities, are the same as for our sample of all firms.

Another approach is to include only those options that had positive trading volume for five days in a row prior to the day on which the return is computed. Again, our main result is unaffected and possibly even stronger than before.

Finally, we move in the opposite direction and include all options in the data set, even those that we previously filtered out because of large price reversals or bid-ask spreads. In this sample, all average returns are higher, a result we attribute to the upward bias in average returns that results from measurement errors, as described by Blume and Stambaugh (1983). Nevertheless, in this sample Monday returns are still the lowest, generally by the same margin as before.

3.3 Subsample results

In Table 7 we examine each year in our sample separately. We do so for several reasons. First, finding a consistent effect across years would indicate that our finding is robust and unlikely to be the result of data mining. Second, if we find that our weekend effect persists in years, like 2002 and 2003, where interest rates were close to zero, then it is unlikely that the effect can be attributed to the costs of maintaining margin requirements, which might be higher over the weekend.

The findings are amazingly consistent across years. In every year, the average return on all options is significantly negative on Mondays. Some Tuesdays are also significantly negative, but with much less regularity. Notably, the average returns are about as negative in 2002 and 2003 as they are in the rest of the sample. Figure 1 shows that during this period T-bill yields were extremely low, and the TED spread (3-month Eurodollars minus 3-month T-bills) was stuck below 25bps. If the cost of maintaining margin is related to interest rates or interest rate spreads, then that cost cannot explain the weekend effect in options, at least completely.

3.4 Time decay and risk

A first reaction to the above results might be to attribute low weekend returns to the negative time decay, or "theta," in option values. In a Black-Scholes world, the price C_t of an option satisfies

$$dC = \frac{\partial C_t}{\partial S_t} dS_t + \frac{\partial C_t}{\partial t} dt + \frac{1}{2} \frac{\partial^2 C_t}{\partial S_t^2} \text{Var}(dS_t).$$

Since the partial derivative $\frac{\partial C_t}{\partial t}$, sometimes known as theta, is negative, the option value will decrease over time if the price of the underlying asset remains constant.

There are several ways to see that this is not a satisfactory explanation of our findings. One is that, in the Black-Scholes model, the price of the underlying asset is a diffusion and therefore never remains constant. In particular, $\text{Var}(dS_t) = \sigma^2 S_t^2 dt$ is always positive, and the positive convexity ("gamma") of the option contract contributes a positive amount to the drift of the option price that approximately cancels out the effects of theta. (When the riskless rate and dividend yield are both zero, this cancellation is exact.) A simpler argument is that under the Black-Scholes model, delta-hedged returns should be approximately riskless. They should therefore command an expected return no higher than the riskless interest rate.

If delta-hedging is imperfect, however, then delta-hedged returns might retain exposures to systematic risk factors, and delta-hedged returns could therefore offer higher or lower expected returns if those risk factors are priced. In the literature on equity index options, delta-hedged option returns are found to be quite negative on average, a result that is often interpreted as compensation for stochastic volatility and jump risks borne by the option writer. If this is the case, then a greater level of risk over the weekend might explain our results. We address this issue in three ways. First, we ask whether there is any evidence that the underlying stocks are riskier over the weekend, either in terms of higher standard deviation or greater departures from normality. Next, we ask whether the option portfolio returns are themselves more volatile. Finally, we examine S&P 500 Index option returns. If weekend risks are priced, then they are likely to be systematic risks that affect the pricing of index options as well.

Table 8 examines the moments of the S&P 500 Index, the average moments of the individual stocks in our sample, and also the moments of first differences in the VIX index. Specifically, the numbers in the tables represent average values of sample moments calculated separately for each firm-year based on daily returns on the underlying asset. We average the sample moments cross sectionally before computing the time series averages and standard errors reported in the table. An advantage of computing moments for each firm-year is that we implicitly weight firms with longer histories more heavily.

For the S&P 500 and the VIX, the cross sectional average is trivial, as there is just one asset in the cross section. For stocks, the cross sectional average is performed three ways: equally weighted, weighted by firm market value (value weighted) at the end of the previous year, and weighted by the average dollar open interest in all options on that firm in the previous year (open interest weighted). All statistics are computed using the same 1996-2007 sample period used elsewhere, except that one year of data must be used to compute open interest weights, so only sample moments starting in 1997 are included in the averages.

A number of findings here deserve our attention. First, we find some evidence that the weekend effect in stocks, reported by Fields (1931) and French (1980), persists through our sample, but only in the equal weighted averages of individual stock moments. The effect is absent from the S&P 500 Index and is undetectable in firm value weighted and open interest weighted averages, suggesting that whatever weekend effect remains in stocks is confined to the smallest firms, for which option open interest is generally small. Nevertheless, for these options the weekend effect must remain fairly large. The average Monday return is around -5bps for the equal weighted portfolio, a full 15bps below the average value for the rest of the week.

While a weekend effect in small stock returns is notable, it cannot explain our findings in the option market for several reasons. First, as noted above, a weekend effect in the underlying stock return might explain some patterns in unhedged option returns, but the effect should be mostly absent from delta-hedged returns. This is not what we find. Furthermore, the weekend effect we find in options exists even for firms in the S&P 100 Index, which represent the largest firms in the market, and for option contracts that have the greatest open interest.

It is more plausible that weekly patterns in second and higher moments of stock returns could explain the weekend effect in option returns, but we find little evidence of such a pattern. Return standard deviation is very flat across all days of the week, confirming French and Roll's (1986) finding that Friday-to-Monday returns are not much different from those of any other close-to-close interval despite being computed over two additional days. This is true both for S&P 500 volatility and for all the averages of individual stock standard deviations.

Skewness does seem slightly lower on Mondays than it is for the rest of the week, though it is still usually positive. To the extent that negative skewness is undesirable from the perspective of an option writer, low Monday skewness could cause negative weekend returns. Still, the effect seems small, and it is also offset by a slightly lower excess kurtosis of stock returns observed for the equal weighted moments. We conclude here that a proper quantification of the effect that lower skewness should have on option returns might be a worthwhile exercise, but that the small differences in skewness make it unlikely to explain our main results.

One intriguing result at the bottom of the table jumps out, namely that changes in the VIX index are systematically higher on Mondays relative to the rest of the week. This turns out to be due to the same technical effect that results from the use of calendar rather than trading time. As described by the CBOE (2009), the VIX index computes maturity as the amount of calendar time until expiration. Despite the fact that the VIX is "model-free" and not a Black-Scholes implied volatility, it nevertheless is measured per unit of time, and the time convention chosen ensures that it will rise predictably over the weekend.

There is no evidence that the volatility of VIX changes is higher over the weekend, which should rule out the possibility that the weekend effect in options is due to time variation in the quantity of variance risk. Since variance risk has been shown by Bakshi, Cao, and Chen (1997) and others to be an important determinant of S&P 500 Index option risk premia, finding that the level of this risk is higer over the weekend might explain our result. No such pattern can be detected.

A more direct examination of the risk-return explanation is to look at the standard deviations of portfolios of options. We do so in Table 9 and find that Mondays are in fact associated with slightly higher levels of riskiness in option returns, particularly among deep out-of-the money contracts. We find this result interesting but note that several hurdles must be overcome before this greater level of risk can be considered an explanation for our results. First, the difference is relatively small relative to the differences in returns. Second, the higher riskiness does not explain why the sign of average delta-hedged returns is often different on Mondays relative to the rest of the week. Equivalently, if we look at the annualized Sharpe ratios on the different portfolios by day of the week, we see large negative numbers for Mondays and generally positive numbers for other days. A simple risk-based explanation would suggest that these Sharpe rations be much more consistent with one another.

Finally, if risk is greater on weekends, and if that risk is priced, then it most likely represents some systematic factor that also drives S&P 500 Index options. For example, if the higher kurtosis we observed for S&P 500 Index returns on Mondays is the explanation for the weekend effect in individual equities, then it seems natural to expect a similar effect in options on the index. We look for such an effect in Table 10. Results for the S&P 500 Index are somewhat inconclusive. Some average Monday returns are significantly negative, but we see no weekend/Monday effect in index options.

Overall, our results suggest that risk may have a possible role in the explanation of lower weekend returns, but the size of the difference between weekend and weekday returns seems too large to be explained by relatively modest differences in riskiness.

3.5 Weekly patterns in liquidity

If observed prices are subject to measurement errors, then average returns will be upward biased, as noted by Blume and Stambaugh (1983). The errors in Blume and Stambaugh's paper arose from the use of transactions prices rather than "true" prices or fundamental values. While our price data consist of bid-ask midpoints and should potentially be less error-prone than transactions prices, Duarte and Jones (2008) show that measurement errors are still prevalent and appear strongly related to the size of the bid-ask spread. A concern therefore is that systematic patterns in bid-ask spreads might generate a weekend effect as an artifact of pure statistical bias.

Table 11 examines bid-ask spreads of options relative to the bid-ask midpoints. Here we are interested in whether Friday spreads are small relative to other days of the week. If so, then the upward bias in Friday to Monday returns will be lower than the bias on other days, which will lead to an observed weekend effect. The bottom line is that Friday spreads are not smaller, except possibly to a degree that is so small that it would have no effect beyond a few basis points. We conclude that bid-ask spreads do not offer any explanations, either related to the Blume and Stambaugh bias or otherwise.

Our second reason to examine liquidity measures follows from the hypothesis of Chen and Singal (2003). If option writers are averse to holding options over the weekend, as their story would suggest, then we might expect systematic differences in open interest or trading volume on different days of the week. In particular, it seems likely that trading volume would have to be higher around the weekend for this explanation to have any validity. A prediction for open interest is more difficult since option positions can be closed out in many different ways, some of which should increase open interest and some of which will reduce it. Nevertheless, we examine both volume and open interest in Table 12. In order to try to standardize volume and open interest across option written on very heterogeneous firms, we report dollar open interest and volume as a fraction of the market capitalization of the firm. Unfortunately, a visual inspection of the numbers in Table 12 reveals no observable patterns whatsoever. Whatever the explanation for the weekend effect is, it is not revealed in this table.

4 Determinants of nontrading returns

In this section we use a regression framework to address the determinants of nontrading returns. These determinants will include the length of the nontrading period as well as a number of variables that represent the conditions of the option and underlying markets.

In all the regressions we run, the dependent variable is the excess return on a portfolio of delta-hedged option positions. We consider both equal weighted and value weighted portfolios, where value weighted (VW) portfolios weight contacts by the dollar value of their open interest. In every case, portfolios are double-sorted on the basis of delta and maturity.

All regressions use ordinary least squares and are pooled across time and portfolios. Because of significant cross-correlations, standard errors are clustered by date. The so-called Rogers clustering we use also adjusts the standard errors for conditional heteroskedasticity. In addition, to account for portfolio-level heterogeneity, we include portfolio fixed effects. This has virtually no effect on any of our results except to increase the R-squares.

4.1 Midweek holidays and long weekends

While we have already established that weekend returns are significantly different from weekday returns, we have yet to directly analyze midweek holidays and long weekends. We do so by regressing portfolio-level excess delta-hedged returns on three dummy variables. The first is set to one if the return is computed over any interval that includes a non-trading period. These are, of course, most often weekends, but they include mid-week holidays as well. The second dummy is set to one if the non-trading period is a mid-week holiday. This variable therefore represents the marginal effect of the non-trading effect being a mid-week holiday. The third dummy variable is equal to one if the non-trading period is a long weekend of three or more days. As with the previous variable, this represents a marginal effect rather than the total effect of the three-day weekend on returns.

In addition to regressions based on the full sample, we also report results based on more liquid subsamples. In one pair of regressions, we only include options on stocks that are members of the S&P 100. In another pair, we only include option contracts that had positive trading volume for five days in a row prior to the day on which the return is computed.

Table 13 contains the results of these regressions. In every case, the non-trading dummy is highly significant, with t statistics ranging from 4.85 to 11.15 in absolute value. The size of the effect is fairly consistent across specifications as well, with non-trading periods having returns that are lower by about one percent. The results for value weighted portfolios are moderately weaker than those of the equal weighted portfolios, and the effect in the more liquid subsamples are just slighly reduced from the full sample, but for all portfolios the non-trading dummy is highly significant.

The mid-week holiday dummy is only significant for the full sample equal weighted portfolios, but its positive sign suggests that mid-week holidays are significantly different from weekends. Specifically, mid-week holidays have average returns that are not as negative as weekends. The long weekend dummy is never significant, possibly the result of usually having a small number of extended weekends each year.

The bottom of the table reports sums of some of the coefficients. These sums represent the total effect of mid-week holidays or long weekends rather than the incremental effect over and above the generic non-trading effect. The results here are not always significant, again probably due to the low numbers of mid-week holidays and long weekends. Only in half the cases can we verify that mid-week holiday returns are significantly lower than regular mid-week returns, with a magnitude that is about around two thirds as big as the weekend effect. We cannot find any significance for the total effect of long weekends.

4.2 Limits of arbitrage

For the weekend effect to persist in markets where traders are aware of its existence, it seems natural to imagine that there are limits to arbitrage of the sort discussed by Shleifer and Vishny (1997). For instance, as we discussed above, the cost of maintaining the margin required to write options should be related to interest rate spreads. Though we found that the weekend effect persists in periods when the TED spread is low, there still may be a relation that is not apparent from casual inspection. We therefore consider the TED spread as an explanatory variable for option returns.

Since the limits of arbitrage should be related to the amount of capital available to the arbitraguers, it seems possible that prior option returns might have some effect on prices. Specifically, we consider the possibility that option writers tend to require higher rates of return following periods in which their portfolios lose value as a result of positive delta-hedged option returns. To capture this effect, we include the lagged 5-day delta-hedged excess return on a value weighted portfolio (weights proportional to the dollar value of open interest) of all equity options.

High volatility should make arbitrage strategies riskier and therefore less easy to implement on a large scale. As a proxy for volatility we use a 44-day rolling volatility computed from S&P 500 Index returns. We also use the VIX index as a robustness check, even though the mechanically-induced weekly seasonal in VIX discussed in Section 3.4 gives VIX an unfair advantage in explaining weekend effects.

Finally, we include an additional dummy variable that is equal to one if the return interval includes an expiration weekend. Since the expiring options do not have market prices on the Monday following expiration weekend, the dummy variable can only effect options that are not expiring. We include this variable because expiration weekend may be associated with higher than usual turnover from expiring to longer dated options. It is possible that this higher turnover could exhaust the limited capital of options writers more quickly.

Results for equal weighted portfolios are reported in Table 14. We include a variety of regressions to highlight different effects. In most regressions, we include explanatory variables by themselves and also with an interaction with the non-trading dummy. The regression method is identical to that of the previous section.

Several results are notable. First, the expiration weekend dummy is highly significant whether or not the other explanatory variables are included. On average, expiration weekend returns are lower than other non-trading returns by about half of a percent. Including this coefficient has just a slightly moderating effect on the generic non-trading dummy.

The lagged average five-day delta-hedged return is highly significant, which could indicate some kind of short-term momentum. It might also represent the kind of spurious autocorrelation identified by Fisher (1966). What is more interesting is that the effect reverses over the weekend, with high past delta-hedged returns predicting low weekend returns. While the positive momentum during the week is inconsistent with the limits to arbitrage story, the negative weekend effect is consistent. Unfortunately, this effect is only significant in the regression with few other explanatory variables.

The effect of the TED spread on average returns also changes sign when it is interacted with the non-trading dummy. During the week, higher TED spreads predict higher option returns.

Over the weekend or during other non-trading periods, high TED spreads forecast lower returns. Both effects are statistically significant, at least marginally, in all the specifications in which they appear. Again, however, only the interaction with the non-trading dummy yields a coefficient that is consistent with our limits to arbitrage story.

Both volatility proxies enter the regression with similar effects. The midweek effect is generally positive, thought not always significantly so. The effect on non-trading periods, however, is negative, with higher volatility forecasting lower returns over non-trading intervals. As with the previous two variables, only the non-trading effect is consistent with limits to arbitrage.

Regressions using value weighted portfolios are presented in Table 15. In general, results are weaker than they were for equal weighted portfolios. Nevertheless, the value weighted results still demonstrate signficiantly lower returns over expiration weekends and during non-trading periods when the TED spread and rolling volatilities are high.

In summary, the results in Tables 14 and 15 are generally consistent with a limits to arbitrage story, but one that only applies over non-trading periods. The two tables also include a number of cases in which the inclusion of other variables eliminates the significance of the non-trading dummy. We note that this does not mean that the regression "explains" the weekend effect, because the variables that must be added to make the non-trading dummy insignificant are themselves interaction terms with the same dummy. When we include all the explanatory variables except the interaction terms, reported in the last column of the two tables, the significance of the non-trading dummy is as strong as it was without the additional explanatory variables. Rather than offering an explanation of the weekend effect, these regressions are more accurately interpreted as measuring the magnitude of the effect in different market conditions.

5 Conclusions

We have demonstrated that a weekend effect exists in the returns, both hedged and unhedged, and implied volatilities of individual equity options. The finding is robust to sample period, the method of portfolio construction, and the selection of the sample.

Regression results provide some evidence that the effect exists during mid-week holidays as well, though possibly with a smaller magnitude. Returns are especially negative over expiration weekends and during non-trading periods in which past delta-hedged returns, TED spreads, and market volatilities are high. We argue that these results are consistent with limits to arbitrage that prevent option writers from fully profiting from anomalous weekend returns.

We believe that our results lend some support to the Chen and Singal (2003) hypothesis that investors try to close out positions that expose them to unbounded downside risk prior to the start of the weekend. This support is limited by the fact that we find no weekly pattern in option volume that would suggest that trading around weekends is common. It is stengthened by the finding that variables that proxy for limits to arbitrage forecast future returns in a manner consistent with that theory only over non-trading periods.

The fact that option returns have a weekly seasonal has two other implications. One is that option pricing models that rely on risk premia for stochastic volatility or jumps must also explain why such premia are primarily manifested over weekends. This seems to us like a challenging restriction that most models would likely fail.

In addition, we believe that our results make the data mining explanation of the original weekend effect, as articulated by Sullivan, Timmermann, and White (2001), somewhat less appealing. While the weekend effect may have disappeared from equity markets, its continued existence in option markets suggests that the effect was real and indicative of economic forces that continue to operate today, though in a slightly different environment.

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Table 1A: Unhedged excess returns by day of the week, delta-sorted portfolios

This table reports average excess returns of portfolios of unhedged equity options. Portfolios are equally weighted across contracts and are formed on the basis of delta. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007. Values that are statistically significant at the 5% level are printed in bold type. Negative numbers are in red.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts & Calls	All Deltas	**-0.62%**	0.07%	**0.22%**	**0.21%**	0.06%	**-16.80**	1.62	**6.15**	**6.81**	1.91
Puts	All Deltas	**-0.50%**	-0.01%	-0.24%	-0.04%	-0.33%	**-2.00**	-0.06	-1.17	-0.17	-1.58
	-.01 > Delta > -.10	**-1.55%**	0.13%	0.00%	0.40%	-0.48%	**-2.82**	0.30	-0.01	0.98	-1.23
	-.10 > Delta > -.25	**-1.21%**	0.11%	-0.09%	0.31%	-0.34%	**-2.92**	0.33	-0.30	0.93	-1.08
	-.25 > Delta > -.50	**-0.87%**	-0.02%	-0.23%	0.09%	-0.39%	**-2.64**	-0.07	-0.87	0.33	-1.51
	-.50 > Delta > -.75	-0.48%	-0.05%	-0.29%	-0.03%	-0.35%	-1.84	-0.21	-1.32	-0.14	-1.64
	-.75 > Delta > -.90	-0.16%	-0.09%	-0.31%	-0.13%	-0.30%	-0.78	-0.50	-1.74	-0.69	-1.80
	-.90 > Delta > -.99	-0.05%	-0.13%	**-0.34%**	-0.24%	**-0.27%**	-0.33	-0.99	**-2.57**	-1.64	**-2.06**
Calls	All Deltas	**-0.78%**	0.20%	**0.68%**	0.47%	0.49%	**-2.80**	0.71	**2.62**	1.80	1.95
	.01 < Delta < .10	-0.78%	1.15%	**2.34%**	1.85%	1.63%	-0.53	1.06	**2.41**	1.70	1.55
	.10 < Delta < .25	**-2.32%**	0.62%	**2.23%**	**1.50%**	**1.09%**	**-4.60**	1.11	**4.18**	**2.96**	**2.25**
	.25 < Delta < .50	**-1.58%**	0.35%	**1.32%**	**0.94%**	**0.74%**	**-4.08**	0.88	**3.55**	**2.55**	**2.11**
	.50 < Delta < .75	**-0.91%**	0.22%	**0.77%**	0.51%	0.52%	**-2.98**	0.72	**2.76**	1.77	1.91
	.75 < Delta < .90	-0.47%	0.13%	**0.45%**	0.27%	0.37%	-1.89	0.55	**2.04**	1.14	1.73
	.90 < Delta < .99	-0.14%	0.05%	0.22%	0.10%	0.21%	-0.75	0.29	1.35	0.56	1.34

Table 1B: Delta-hedged excess returns by day of the week, delta-sorted portfolios

This table reports average excess returns of portfolios of delta-hedged equity options. Portfolios are equally weighted across contracts and are formed on the basis of delta. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts & Calls	All Deltas	**-0.52%**	**0.11%**	**0.25%**	**0.27%**	**0.08%**	**-13.71**	**3.74**	**10.48**	**11.17**	**3.09**
Puts	All Deltas	**-0.87%**	**-0.14%**	**0.09%**	0.07%	**-0.05%**	**-21.93**	**-4.61**	**4.08**	1.82	**-2.23**
	-.01 > Delta > -.10	**-2.49%**	**-0.81%**	0.02%	0.00%	**-0.48%**	**-9.56**	**-4.46**	0.11	0.02	**-3.42**
	-.10 > Delta > -.25	**-1.88%**	**-0.37%**	**0.20%**	**0.18%**	**-0.17%**	**-16.40**	**-4.77**	**3.19**	**2.01**	**-2.44**
	-.25 > Delta > -.50	**-1.33%**	**-0.19%**	**0.17%**	0.13%	**-0.09%**	**-21.02**	**-4.07**	**5.04**	1.81	**-2.36**
	-.50 > Delta > -.75	**-0.82%**	**-0.09%**	**0.12%**	**0.08%**	-0.03%	**-23.41**	**-3.43**	**5.66**	**1.97**	-1.38
	-.75 > Delta > -.90	**-0.37%**	**-0.03%**	**0.06%**	**0.07%**	0.00%	**-19.17**	**-2.28**	**4.97**	**3.03**	0.32
	-.90 > Delta > -.99	**-0.19%**	**-0.07%**	**-0.04%**	**-0.04%**	**-0.04%**	**-16.56**	**-7.70**	**-4.60**	**-2.45**	**-4.40**
Calls	All Deltas	**-0.19%**	**0.35%**	**0.41%**	**0.46%**	**0.21%**	**-3.93**	**8.96**	**12.82**	**10.66**	**6.39**
	.01 < Delta < .10	0.75%	**1.34%**	**1.63%**	**2.16%**	1.61%	0.63	**2.20**	**3.25**	**3.11**	1.78
	.10 < Delta < .25	**-0.86%**	**1.19%**	**1.46%**	**1.57%**	**0.57%**	**-4.15**	**7.19**	**10.11**	**10.61**	**4.25**
	.25 < Delta < .50	**-0.71%**	**0.58%**	**0.77%**	**0.89%**	**0.32%**	**-7.44**	**7.42**	**12.56**	**10.99**	**5.28**
	.50 < Delta < .75	**-0.29%**	**0.35%**	**0.42%**	**0.51%**	**0.19%**	**-6.00**	**8.80**	**14.32**	**8.85**	**6.22**
	.75 < Delta < .90	-0.02%	**0.25%**	**0.26%**	**0.31%**	**0.15%**	-0.59	**11.41**	**16.31**	**9.10**	**8.83**
	.90 < Delta < .99	**0.12%**	**0.14%**	**0.11%**	**0.14%**	**0.09%**	**9.66**	**12.95**	**13.70**	**6.95**	**9.72**

Table 2: Delta-hedged excess returns by day of the week, maturity-sorted portfolios

This table reports average excess returns of portfolios of delta-hedged equity options. Portfolios are equally weighted across contracts and are formed on the basis of maturity. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts	1-10 days	**-1.66%**	-0.11%	**0.34%**	0.02%	**-0.27%**	**-16.31**	-1.53	**3.72**	0.18	**-2.50**
	11-53 days	**-1.15%**	**-0.19%**	**0.11%**	0.06%	**-0.10%**	**-22.15**	**-5.10**	**3.91**	1.11	**-3.24**
	54-118 days	**-0.64%**	**-0.12%**	**0.07%**	0.05%	-0.01%	**-18.67**	**-4.56**	**3.92**	1.39	-0.55
	119-252 days	**-0.49%**	**-0.09%**	**0.05%**	**0.06%**	-0.01%	**-16.86**	**-4.09**	**3.11**	**2.78**	-0.45
	253+ days	0.64%	0.01%	0.48%	0.01%	0.01%	0.73	0.05	1.49	0.04	0.05
Calls	1-10 days	**-0.41%**	**0.75%**	**0.78%**	**0.86%**	**0.43%**	**-4.23**	**7.51**	**8.53**	**7.08**	**4.26**
	11-53 days	**-0.32%**	**0.44%**	**0.52%**	**0.59%**	**0.24%**	**-5.02**	**8.66**	**12.70**	**9.01**	**5.80**
	54-118 days	-0.08%	**0.26%**	**0.33%**	**0.38%**	**0.20%**	-1.91	**8.38**	**12.66**	**10.92**	**7.29**
	119-252 days	-0.04%	**0.19%**	**0.24%**	**0.28%**	**0.17%**	-1.03	**7.59**	**11.66**	**11.74**	**7.92**
	253+ days	-0.23%	0.23%	0.04%	-0.49%	**0.28%**	-1.46	0.81	0.22	-1.03	**1.97**

Table 3: First day of the week versus other days

This table reports differences between the average excess returns on delta-hedged equity options on the first day of the week (Monday unless it is a holiday) and the remainder of the week. Portfolios are equally weighted across contracts and are formed on the basis of delta. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Means			T statistics		
		11-53 days	54-118 days	119-252 days	11-53 days	54-118 days	119-252 days
Puts & Calls	All Deltas						
Puts	All Deltas	**-1.17%**	**-0.69%**	**-0.53%**	**-24.05**	**-24.40**	**-23.70**
	-.01 > Delta > -.10	**-4.05%**	**-2.29%**	**-1.50%**	**-5.99**	**-9.75**	**-7.70**
	-.10 > Delta > -.25	**-4.04%**	**-1.61%**	**-1.01%**	**-18.68**	**-21.02**	**-21.81**
	-.25 > Delta > -.50	**-2.64%**	**-0.99%**	**-0.64%**	**-22.31**	**-25.43**	**-25.07**
	-.50 > Delta > -.75	**-1.33%**	**-0.50%**	**-0.33%**	**-24.27**	**-25.16**	**-22.86**
	-.75 > Delta > -.90	**-0.45%**	**-0.19%**	**-0.15%**	**-21.47**	**-17.92**	**-11.45**
	-.90 > Delta > -.99	**-0.14%**	**-0.09%**	**-0.09%**	**-12.25**	**-9.36**	**-4.97**
Calls	All Deltas	**-0.79%**	**-0.41%**	**-0.29%**	**-14.23**	**-13.13**	**-12.25**
	.01 < Delta < .10	-0.45%	**-1.52%**	**-1.49%**	-0.24	**-2.60**	**-2.10**
	.10 < Delta < .25	**-3.21%**	**-1.64%**	**-1.05%**	**-8.89**	**-12.33**	**-10.13**
	.25 < Delta < .50	**-2.44%**	**-0.96%**	**-0.61%**	**-15.70**	**-16.41**	**-15.18**
	.50 < Delta < .75	**-1.19%**	**-0.41%**	**-0.26%**	**-17.13**	**-14.25**	**-12.72**
	.75 < Delta < .90	**-0.38%**	**-0.12%**	**-0.06%**	**-13.22**	**-7.18**	**-3.97**
	.90 < Delta < .99	-0.01%	**0.02%**	0.02%	-0.50	**2.33**	1.03

Table 4: Weekday effects in other variables

This table reports weekday effects in five variables. For each, we report equal weighted averages across all contracts. The simple unhedged and delta-hedged returns are identical to the returns used above except that they are not in excess of the riskless rate. The change in unadjusted implied volatility is the average first difference of the implied volatilities as calculated by Optionmetrics. The change in adjusted implied volatility uses implied volatilities that are quoted in terms of business days rather than calendar days. The change in total implied volatility looks at the change in cumulative-until-expiration implied volatility. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Simple unhedged return	Puts & Calls	**-0.58%**	0.09%	**0.24%**	**0.22%**	**0.07%**	**-15.89**	1.95	**6.47**	**7.17**	**2.29**
	Puts	-0.47%	0.00%	-0.23%	-0.03%	-0.31%	-1.86	0.01	-1.11	-0.12	-1.53
	Calls	**-0.75%**	0.21%	**0.69%**	0.48%	**0.50%**	**-2.67**	0.76	**2.66**	1.85	**2.00**
Simple delta-hedged return	Puts & Calls	**-0.50%**	**0.12%**	**0.25%**	**0.27%**	**0.08%**	**-13.29**	**3.96**	**10.68**	**11.37**	**3.29**
	Puts	**-0.66%**	-0.05%	**0.16%**	**0.14%**	0.01%	**-16.97**	-1.79	**7.07**	**3.64**	0.56
	Calls	**-0.35%**	**0.28%**	**0.35%**	**0.41%**	**0.15%**	**-7.26**	**7.18**	**11.15**	**9.43**	**4.76**
Change in unadjusted implied vol	Puts & Calls	**0.77%**	**0.37%**	**0.33%**	**0.32%**	**0.22%**	**23.57**	**19.44**	**20.66**	**19.68**	**12.50**
	Puts	**0.74%**	**0.37%**	**0.33%**	**0.29%**	**0.22%**	**18.35**	**14.62**	**13.44**	**12.24**	**8.30**
	Calls	**0.80%**	**0.37%**	**0.33%**	**0.34%**	**0.22%**	**27.03**	**19.04**	**22.24**	**22.52**	**13.73**
Change in adjusted implied vol	Puts & Calls	**-0.57%**	**0.63%**	**0.97%**	**1.46%**	**0.68%**	**-18.51**	**17.39**	**27.21**	**23.76**	**24.15**
	Puts	**-0.63%**	**0.62%**	**0.97%**	**1.42%**	**0.69%**	**-15.68**	**14.91**	**22.18**	**21.60**	**17.60**
	Calls	**-0.51%**	**0.62%**	**0.96%**	**1.46%**	**0.66%**	**-18.60**	**17.63**	**29.07**	**24.25**	**26.43**
Change in total implied vol	Puts & Calls	**-8.29%**	**-3.62%**	**-3.07%**	**-3.34%**	**-2.74%**	**-40.81**	**-22.32**	**-27.08**	**-24.28**	**-21.47**
	Puts	**-8.66%**	**-3.65%**	**-3.10%**	**-3.62%**	**-2.66%**	**-34.13**	**-17.84**	**-18.33**	**-19.94**	**-14.10**
	Calls	**-7.89%**	**-3.59%**	**-3.03%**	**-3.06%**	**-2.77%**	**-42.83**	**-23.24**	**-27.48**	**-22.43**	**-22.77**

Table 5A: Unhedged excess returns by day of the week, delta-sorted portfolios, value-weighted

This table reports average excess returns of portfolios of unhedged equity options. Portfolios are value weighted and are formed on the basis of delta, where the value of each option contract is taken to be the market value of open interest. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts & Calls	All Deltas	-0.17%	-0.09%	0.13%	0.03%	0.00%	-1.48	-0.83	1.32	0.30	0.00
Puts	All Deltas	-0.52%	-0.16%	**-0.51%**	0.06%	-0.27%	-1.72	-0.59	**-2.02**	0.21	-1.15
	-.01 > Delta > -.10	**-1.83%**	-0.42%	-0.15%	0.40%	-0.40%	**-2.82**	-0.90	-0.33	0.87	-0.94
	-.10 > Delta > -.25	**-1.51%**	-0.32%	-0.44%	0.59%	-0.33%	**-2.83**	-0.77	-1.17	1.41	-0.89
	-.25 > Delta > -.50	**-1.02%**	-0.24%	-0.53%	0.29%	-0.35%	**-2.48**	-0.67	-1.60	0.84	-1.10
	-.50 > Delta > -.75	-0.48%	-0.17%	**-0.54%**	0.04%	-0.30%	-1.48	-0.60	**-1.99**	0.13	-1.19
	-.75 > Delta > -.90	-0.15%	-0.10%	**-0.47%**	-0.17%	-0.23%	-0.64	-0.44	**-2.19**	-0.76	-1.17
	-.90 > Delta > -.99	-0.06%	-0.14%	**-0.54%**	-0.25%	-0.22%	-0.31	-0.81	**-3.06**	-1.33	-1.41
Calls	All Deltas	-0.24%	-0.05%	0.42%	0.18%	0.03%	-0.92	-0.20	1.69	0.72	0.11
	.01 < Delta < .10	0.86%	-0.35%	1.12%	0.07%	-0.46%	0.36	-0.32	1.13	0.07	-0.36
	.10 < Delta < .25	**-1.62%**	-0.06%	**1.91%**	0.77%	-0.14%	**-2.81**	-0.11	**3.23**	1.41	-0.28
	.25 < Delta < .50	**-1.01%**	0.04%	**1.30%**	0.60%	0.04%	**-2.36**	0.10	**3.10**	1.48	0.11
	.50 < Delta < .75	-0.35%	0.03%	**0.75%**	0.26%	0.10%	-1.04	0.08	**2.41**	0.84	0.33
	.75 < Delta < .90	-0.08%	0.03%	0.40%	0.06%	0.13%	-0.29	0.13	1.67	0.26	0.56
	.90 < Delta < .99	0.06%	-0.01%	0.11%	0.00%	0.06%	0.33	-0.07	0.66	0.00	0.40

Table 5B: Delta-hedged excess returns by day of the week, delta-sorted portfolios, value-weighted

This table reports average excess returns of portfolios of delta-hedged equity options. Portfolios are value weighted and are formed on the basis of delta, where the value of each option contract is taken to be the market value of open interest. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts & Calls	All Deltas	**-0.21%**	0.05%	**0.12%**	**0.15%**	-0.03%	**-5.56**	1.70	**5.82**	**6.78**	-1.56
Puts	All Deltas	**-0.78%**	**-0.16%**	0.04%	0.00%	**-0.16%**	**-10.22**	**-3.73**	1.16	-0.06	**-4.99**
	-.01 > Delta > -.10	**-1.99%**	**-0.44%**	0.14%	-0.26%	-0.40%	**-5.25**	**-2.15**	0.85	-1.26	-1.79
	-.10 > Delta > -.25	**-1.73%**	**-0.39%**	0.15%	0.12%	**-0.35%**	**-9.05**	**-3.93**	1.66	0.99	**-3.40**
	-.25 > Delta > -.50	**-1.29%**	**-0.26%**	**0.11%**	0.07%	**-0.27%**	**-10.88**	**-3.88**	**2.01**	0.81	**-5.00**
	-.50 > Delta > -.75	**-0.72%**	**-0.15%**	**0.06%**	0.04%	**-0.16%**	**-11.63**	**-3.22**	**2.01**	1.04	**-5.16**
	-.75 > Delta > -.90	**-0.37%**	**-0.08%**	0.01%	-0.02%	**-0.06%**	**-6.53**	**-2.75**	0.37	-0.62	**-3.33**
	-.90 > Delta > -.99	**-0.20%**	**-0.07%**	**-0.07%**	**-0.08%**	**-0.04%**	**-5.65**	**-3.07**	**-4.49**	**-2.74**	**-2.53**
Calls	All Deltas	-0.05%	**0.15%**	**0.19%**	**0.23%**	0.02%	-0.93	**4.52**	**6.70**	**7.19**	0.60
	.01 < Delta < .10	0.61%	-0.07%	0.33%	0.70%	0.71%	0.35	-0.13	0.67	1.12	0.49
	.10 < Delta < .25	**-0.83%**	0.38%	**0.60%**	**0.97%**	-0.24%	**-2.40**	1.89	**3.38**	**5.27**	-1.23
	.25 < Delta < .50	**-0.57%**	**0.29%**	**0.49%**	**0.65%**	-0.10%	**-3.93**	**3.21**	**6.12**	**7.41**	-1.23
	.50 < Delta < .75	-0.11%	**0.25%**	**0.30%**	**0.38%**	0.02%	-1.48	**5.36**	**7.55**	**8.41**	0.50
	.75 < Delta < .90	0.07%	**0.18%**	**0.16%**	**0.20%**	**0.06%**	1.61	**6.60**	**7.85**	**8.03**	**3.15**
	.90 < Delta < .99	**0.12%**	**0.09%**	**0.07%**	**0.10%**	**0.05%**	**6.22**	**6.81**	**5.23**	**4.26**	**4.16**

Table 6: Alternative sampling procedures

This table reports average excess returns and average changes in adjusted implied volatility of portfolios of delta-hedged equity options. Portfolios are equally weighted across contracts and are formed on the basis of delta. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
							Delta-hedged excess returns				
Only firms that are in the S&P 100	Puts & Calls	**-0.49%**	0.05%	**0.21%**	**0.26%**	0.06%	**-8.15**	1.42	**6.92**	**7.48**	1.67
	Puts	**-1.26%**	**-0.30%**	0.01%	0.09%	-0.12%	**-9.61**	**-4.25**	0.14	1.38	-1.96
	Calls	0.13%	**0.35%**	**0.38%**	**0.42%**	**0.20%**	1.29	**5.41**	**8.24**	**8.07**	**3.93**
Only options w/ 5 consecutive days of volume > 0	Puts & Calls	**-0.83%**	**0.46%**	**0.73%**	**0.73%**	-0.06%	**-4.78**	**5.01**	**9.03**	**9.09**	-0.71
	Puts	**-2.67%**	**-0.63%**	0.06%	0.03%	**-0.74%**	**-13.51**	**-5.04**	0.49	0.29	**-7.04**
	Calls	-0.17%	**0.91%**	**1.02%**	**1.04%**	**0.22%**	-0.88	**8.28**	**10.83**	**10.89**	**2.20**
No filters to exclude errors & large spreads	Puts & Calls	**0.37%**	**1.42%**	**1.61%**	**1.75%**	**1.36%**	**2.63**	**11.47**	**16.05**	**14.81**	**9.50**
	Puts	-0.13%	**1.04%**	**1.44%**	**1.45%**	**1.10%**	-1.13	**9.57**	**15.21**	**12.41**	**13.04**
	Calls	**0.87%**	**1.79%**	**1.77%**	**2.05%**	**1.61%**	**3.60**	**7.75**	**8.93**	**9.44**	**5.69**
							Changes in adjusted implied volatilities				
Only firms that are in the S&P 100	Puts & Calls	**-0.26%**	**0.51%**	**0.76%**	**1.15%**	**0.50%**	**-8.97**	**16.68**	**23.87**	**22.15**	**20.60**
	Puts	**-0.27%**	**0.44%**	**0.69%**	**1.08%**	**0.51%**	**-6.55**	**12.39**	**17.72**	**19.67**	**14.45**
	Calls	**-0.25%**	**0.55%**	**0.81%**	**1.19%**	**0.49%**	**-8.26**	**15.41**	**22.26**	**21.16**	**17.61**

Table 7: Average delta-hedged excess returns for each year of the sample

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
1996	Puts & Calls	**-0.70%**	**0.22%**	**0.29%**	**0.28%**	**0.16%**	**-8.99**	**2.70**	**5.83**	**4.71**	**2.60**
	Puts	**-1.13%**	-0.19%	0.08%	0.07%	0.02%	**-10.95**	-1.94	1.62	0.98	0.25
	Calls	**-0.34%**	**0.57%**	**0.47%**	**0.47%**	**0.29%**	**-3.28**	**4.66**	**5.48**	**5.85**	**4.42**
1997	Puts & Calls	**-0.49%**	**0.26%**	**0.27%**	**0.32%**	**0.21%**	**-2.47**	**2.03**	**6.11**	**5.77**	**3.88**
	Puts	**-1.05%**	-0.09%	0.02%	0.11%	0.09%	**-4.60**	-1.15	0.23	1.76	1.25
	Calls	-0.03%	**0.57%**	**0.50%**	**0.50%**	**0.31%**	-0.16	**2.81**	**8.53**	**6.18**	**4.26**
1998	Puts & Calls	**-0.50%**	**0.26%**	**0.34%**	**0.58%**	**0.29%**	**-3.10**	**2.47**	**4.81**	**3.97**	**3.17**
	Puts	**-1.01%**	-0.10%	0.13%	**0.31%**	0.10%	**-7.53**	-0.90	1.70	**2.71**	1.21
	Calls	0.04%	**0.64%**	**0.59%**	**0.88%**	**0.50%**	0.17	**4.07**	**5.77**	**4.04**	**3.74**
1999	Puts & Calls	**-0.81%**	0.15%	**0.37%**	**0.34%**	0.09%	**-10.10**	1.61	**5.68**	**6.06**	1.50
	Puts	**-1.23%**	-0.18%	**0.30%**	0.14%	-0.08%	**-12.32**	-1.39	**3.58**	1.45	-1.12
	Calls	**-0.42%**	**0.46%**	**0.44%**	**0.53%**	**0.26%**	**-4.35**	**5.49**	**6.63**	**10.21**	**3.94**
2000	Puts & Calls	**-0.68%**	**0.54%**	**0.74%**	**0.65%**	**0.45%**	**-5.32**	**3.48**	**5.38**	**5.73**	**2.46**
	Puts	**-1.14%**	0.12%	**0.40%**	**0.41%**	0.18%	**-7.88**	0.84	**3.17**	**3.41**	1.22
	Calls	-0.20%	**0.97%**	**1.11%**	**0.90%**	**0.74%**	-1.37	**5.18**	**6.54**	**6.41**	**3.12**
2001	Puts & Calls	**-0.67%**	-0.12%	**0.32%**	**0.26%**	-0.02%	**-2.74**	-1.31	**2.44**	**3.06**	-0.20
	Puts	**-0.82%**	**-0.19%**	0.15%	0.14%	-0.12%	**-4.22**	**-2.35**	1.60	1.90	-1.47
	Calls	-0.49%	-0.04%	**0.52%**	**0.40%**	0.10%	-1.51	-0.32	**2.85**	**3.38**	0.78
2002	Puts & Calls	**-0.41%**	**0.19%**	**0.26%**	**0.26%**	0.04%	**-4.36**	**2.02**	**3.23**	**3.69**	0.52
	Puts	**-0.56%**	0.03%	**0.15%**	**0.15%**	-0.05%	**-6.05**	0.36	**2.24**	**2.12**	-0.74
	Calls	-0.23%	**0.40%**	**0.41%**	**0.42%**	0.15%	-1.85	**3.11**	**3.28**	**4.47**	1.57
2003	Puts & Calls	**-0.46%**	**-0.15%**	0.06%	0.02%	**-0.12%**	**-6.82**	**-2.74**	1.27	0.37	**-2.60**
	Puts	**-0.61%**	**-0.26%**	0.00%	-0.07%	**-0.19%**	**-5.05**	**-4.23**	-0.02	-1.17	**-3.12**
	Calls	**-0.34%**	-0.04%	**0.12%**	0.10%	-0.05%	**-3.62**	-0.61	**2.50**	1.59	-0.88
2004	Puts & Calls	**-0.39%**	-0.07%	0.08%	**0.10%**	-0.03%	**-6.24**	-1.50	1.71	**2.45**	-0.63
	Puts	**-0.70%**	**-0.24%**	-0.03%	-0.03%	-0.10%	**-9.44**	**-3.47**	-0.52	-0.63	-1.91
	Calls	-0.11%	0.08%	**0.19%**	**0.22%**	0.04%	-1.44	1.53	**3.41**	**4.22**	0.65
2005	Puts & Calls	**-0.42%**	-0.02%	**0.12%**	**0.18%**	-0.04%	**-8.76**	-0.54	**2.36**	**3.03**	-0.97
	Puts	**-0.71%**	**-0.24%**	0.02%	-0.33%	**-0.17%**	**-13.30**	**-3.77**	0.29	-1.01	**-2.52**
	Calls	**-0.15%**	**0.18%**	**0.21%**	0.65%	0.08%	**-2.28**	**3.50**	**3.39**	1.90	1.45
2006	Puts & Calls	**-0.26%**	-0.03%	0.03%	0.05%	**-0.11%**	**-3.51**	-0.45	0.63	0.84	**-2.19**
	Puts	**-0.62%**	**-0.16%**	-0.09%	-0.08%	**-0.23%**	**-7.45**	**-2.24**	-1.49	-1.08	**-3.39**
	Calls	0.07%	0.10%	**0.14%**	**0.16%**	0.01%	0.69	1.05	**1.99**	**2.55**	0.09
2007	Puts & Calls	**-0.34%**	0.05%	-0.06%	0.08%	-0.07%	**-3.14**	0.20	-1.16	0.93	-0.88
	Puts	**-0.75%**	-0.11%	-0.10%	-0.05%	-0.12%	**-5.68**	-0.42	-1.04	-0.44	-1.31
	Calls	0.01%	0.18%	-0.04%	0.18%	-0.02%	0.05	0.77	-0.47	1.69	-0.17

Table 8: Stock return and VIX moments by day of the week

This table reports average firm-year moments for S&P 500 Index and individual equity returns as well as first differences in the VIX Index. Data are daily from January 4, 1996, through June 31, 2007, though one year of data must be used to compute open interest weights, so only sample moments starting in 1997 are included in the averages.

	Mon	Tues	Weds	Thurs	Fri	T-F	Mon - T-F
				S&P 500 Index			
Mean (bps.)	4.98	5.07	3.81	1.79	0.72	2.85	2.13
	(1.39)	(0.55)	(0.54)	(0.32)	(0.13)	(1.25)	(0.64)
Standard Deviation (%)	1.14	1.11	1.03	1.09	1.06	1.08	0.07
	(8.70)	(9.61)	(9.14)	(10.79)	(9.26)	(10.15)	(0.89)
Skewness	-0.46	0.28	0.14	0.33	-0.16	0.15	-0.61
	(1.30)	(1.67)	(0.99)	(3.28)	(1.71)	(2.95)	(1.66)
Excess Kurtosis	3.01	0.76	0.59	0.85	0.53	0.68	2.32
	(2.27)	(1.50)	(1.75)	(2.77)	(2.63)	(2.95)	(1.89)
				Equal weighted stock average			
Mean (bps.)	-5.22	4.71	8.96	10.44	19.73	10.94	-16.17
	(0.98)	(0.77)	(1.88)	(2.18)	(5.55)	(4.70)	(3.70)
Standard Deviation (%)	4.09	4.06	4.07	4.08	3.98	4.05	0.04
	(11.95)	(11.69)	(11.74)	(11.99)	(11.11)	(11.64)	(1.70)
Skewness	0.32	0.38	0.41	0.40	0.42	0.40	-0.08
	(9.19)	(12.71)	(12.92)	(11.21)	(12.01)	(13.46)	(2.31)
Excess Kurtosis	3.01	3.26	3.41	3.45	3.42	3.39	-0.38
	(30.46)	(41.93)	(33.45)	(31.48)	(31.48)	(35.64)	(3.37)
				Value weighted stock average			
Mean (bps.)	2.43	4.69	6.11	3.75	3.41	4.48	-2.05
	(0.71)	(0.56)	(0.89)	(0.70)	(0.72)	(2.31)	(0.74)
Standard Deviation (%)	2.35	2.33	2.39	2.38	2.25	2.34	0.02
	(9.21)	(8.77)	(8.76)	(9.21)	(8.78)	(8.92)	(0.40)
Skewness	-0.02	0.18	0.21	0.17	0.08	0.16	-0.18
	(0.28)	(3.92)	(5.53)	(4.57)	(1.61)	(5.90)	(2.26)
Excess Kurtosis	2.11	1.87	2.19	2.21	2.13	2.10	0.01
	(13.40)	(18.63)	(21.09)	(16.42)	(12.75)	(19.68)	(0.03)
				Open interest weighted stock average			
Mean (bps.)	3.22	2.67	10.23	7.21	-2.81	4.32	-1.10
	(0.64)	(0.23)	(0.97)	(0.84)	(0.34)	(1.30)	(0.29)
Standard Deviation (%)	2.94	2.93	3.07	3.06	2.82	2.97	-0.03
	(8.77)	(8.22)	(7.44)	(8.28)	(8.34)	(8.10)	(0.40)
Skewness	0.01	0.22	0.25	0.22	0.14	0.21	-0.20
	(0.08)	(4.69)	(3.53)	(6.18)	(2.89)	(9.99)	(2.34)
Excess Kurtosis	1.92	1.65	2.26	2.31	2.19	2.10	-0.18
	(9.75)	(11.68)	(13.66)	(11.06)	(9.90)	(13.24)	(0.81)
				VIX Index (first differences)			
Mean (bps.)	46.74	-7.81	-10.54	-2.21	-25.29	-11.46	58.21
	(6.15)	(1.03)	(1.78)	(0.28)	(3.82)	(6.25)	(6.24)
Standard Deviation (%)	1.24	1.21	1.08	1.25	1.21	1.19	0.06
	(8.29)	(8.21)	(10.28)	(9.01)	(9.22)	(9.72)	(0.58)
Skewness	0.24	0.33	0.24	-0.04	0.63	0.29	-0.06
	(0.68)	(1.19)	(1.81)	(0.13)	(2.66)	(4.07)	(0.15)
Excess Kurtosis	3.82	2.02	1.66	2.42	2.34	2.11	1.71
	(3.24)	(1.86)	(4.02)	(2.34)	(2.49)	(3.13)	(1.15)

Table 9: Risk and Sharpe ratios of portfolios of delta-hedged excess option returns

This table reports standard deviations and Sharpe ratios from excess returns of portfolios of delta-hedged equity options. Portfolios are equally weighted across contracts and are formed on the basis of delta. "All Delta" portfolios include options regardless of delta, even those that are less than .01 or greater than .99 in absolute value. Data are daily from January 4, 1996, through June 31, 2007.

		Standard deviations					Sharpe ratios				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts & Calls	All Deltas	0.88%	0.71%	0.58%	0.57%	0.59%	-9.60	2.52	7.00	7.70	2.20
Puts	All Deltas	0.92%	0.72%	0.55%	0.90%	0.58%	-15.37	-3.16	2.66	1.26	-1.40
	-.01 > Delta > -.10	6.06%	4.44%	3.71%	3.61%	3.39%	-6.68	-2.96	0.09	0.00	-2.30
	-.10 > Delta > -.25	2.67%	1.88%	1.49%	2.19%	1.63%	-11.44	-3.20	2.18	1.34	-1.69
	-.25 > Delta > -.50	1.48%	1.12%	0.83%	1.70%	0.89%	-14.60	-2.76	3.33	1.24	-1.64
	-.50 > Delta > -.75	0.82%	0.65%	0.51%	1.03%	0.51%	-16.25	-2.25	3.82	1.26	-0.96
	-.75 > Delta > -.90	0.45%	0.35%	0.31%	0.56%	0.32%	-13.36	-1.39	3.14	2.03	0.00
	-.90 > Delta > -.99	0.27%	0.22%	0.21%	0.37%	0.21%	-11.43	-5.17	-3.09	-1.76	-3.09
Calls	All Deltas	1.14%	0.95%	0.77%	1.05%	0.78%	-2.71	5.99	8.65	7.12	4.37
	.01 < Delta < .10	27.58%	14.69%	12.09%	16.52%	21.49%	0.44	1.48	2.19	2.12	1.22
	.10 < Delta < .25	4.85%	4.04%	3.50%	3.56%	3.24%	-2.88	4.79	6.78	7.17	2.86
	.25 < Delta < .50	2.23%	1.92%	1.50%	1.94%	1.47%	-5.17	4.91	8.34	7.45	3.54
	.50 < Delta < .75	1.12%	0.98%	0.71%	1.39%	0.72%	-4.21	5.80	9.61	5.96	4.29
	.75 < Delta < .90	0.61%	0.53%	0.38%	0.83%	0.42%	-0.53	7.66	11.12	6.07	5.80
	.90 < Delta < .99	0.30%	0.26%	0.20%	0.50%	0.21%	6.50	8.75	8.94	4.55	6.96

Table 10: Weekday effects in S&P 500 Index options

This table reports mean excess returns and changes in implied volatility of portfolios of delta-hedged S&P 500 Index options. Portfolios are equally weighted across contracts. Data are daily from January 4, 1996, through June 31, 2007.

		Means					T statistics				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Excess unhedged return	Puts & Calls	**-0.60%**	-0.02%	-0.16%	-0.13%	**-0.43%**	**-4.30**	-0.14	-1.36	-1.08	**-3.22**
	Puts	-1.30%	-0.49%	-0.66%	-0.05%	-0.85%	-1.90	-0.72	-1.14	-0.08	-1.33
	Calls	0.34%	0.47%	0.26%	-0.13%	0.05%	0.63	0.84	0.49	-0.26	0.11
Excess delta-hedged return	Puts & Calls	-0.28%	-0.11%	-0.14%	0.03%	**-0.27%**	-1.43	-0.70	-1.36	0.25	**-2.00**
	Puts	**-0.85%**	-0.27%	-0.07%	0.11%	**-0.65%**	**-3.78**	-1.06	-0.40	0.55	**-3.05**
	Calls	0.22%	0.11%	-0.21%	-0.06%	0.11%	0.88	0.65	-1.39	-0.36	0.58
Change in unadjusted implied vol	Puts & Calls	**1.16%**	**0.74%**	**1.02%**	**0.23%**	**0.26%**	**12.97**	**9.14**	**8.45**	**4.05**	**4.09**
	Puts	**0.73%**	**0.32%**	**0.85%**	**0.22%**	-0.05%	**8.57**	**4.06**	**6.32**	**3.22**	-0.55
	Calls	**1.49%**	**1.13%**	**1.07%**	**0.22%**	**0.54%**	**9.36**	**7.14**	**5.52**	**2.03**	**4.48**
Change in adjusted implied vol	Puts & Calls	**0.62%**	**0.97%**	**1.61%**	**1.18%**	**0.51%**	**6.51**	**10.08**	**10.07**	**13.79**	**6.47**
	Puts	**0.32%**	**0.45%**	**1.26%**	**0.82%**	0.09%	**3.32**	**4.96**	**7.35**	**8.77**	0.85
	Calls	**0.84%**	**1.44%**	**1.76%**	**1.42%**	**0.90%**	**4.73**	**7.67**	**7.15**	**9.65**	**6.03**

Table 11: Relative bid-ask spreads, maturity-sorted portfolios

This table reports average bid-ask spreads, measured as a percentage of the bid-ask midpoint, of portfolios of equity options. All figures represent equally weighted averages across contracts. Data are daily from January 4, 1996, through June 31, 2007.

		Means				
		Mon	Tues	Weds	Thurs	Fri
Puts	1-10 days	10.27%	10.39%	10.17%	10.41%	9.61%
	11-53 days	9.37%	9.40%	9.35%	9.34%	9.26%
	54-118 days	8.79%	8.81%	8.76%	8.76%	8.74%
	119-252 days	8.49%	8.49%	8.46%	8.43%	8.44%
	253+ days	7.68%	7.34%	7.10%	7.15%	7.44%
Calls	1-10 days	10.10%	10.10%	9.88%	10.16%	9.57%
	11-53 days	9.45%	9.46%	9.29%	9.29%	9.20%
	54-118 days	8.63%	8.64%	8.53%	8.53%	8.52%
	119-252 days	8.17%	8.17%	8.12%	8.09%	8.10%
	253+ days	5.76%	5.71%	5.42%	6.12%	5.39%

Table 12: Open interest and trading volume by day of the week, maturity-sorted portfolios

This table reports average levels of open interest and trading volume, measured as a fraction of the market capitalization of the underlying firm, of portfolios of equity options. All figures represent equally weighted averages across contracts. Data are daily from January 4, 1996, through June 31, 2007.

		Open interest					Trading volume				
		Mon	Tues	Weds	Thurs	Fri	Mon	Tues	Weds	Thurs	Fri
Puts	1-10 days	0.1055	0.1075	0.1048	0.1063	0.1029	0.0055	0.0061	0.0058	0.0058	0.0049
	11-53 days	0.1008	0.1006	0.0962	0.0952	0.0979	0.0042	0.0048	0.0044	0.0042	0.0042
	54-118 days	0.1020	0.1015	0.1020	0.1017	0.1000	0.0023	0.0029	0.0026	0.0028	0.0024
	119-252 days	0.0920	0.0917	0.0867	0.0900	0.0880	0.0017	0.0020	0.0019	0.0019	0.0017
	253+ days	0.1613	0.1641	0.1974	0.1470	0.1353	0.0028	0.0037	0.0046	0.0026	0.0028
Calls	1-10 days	0.1537	0.1555	0.1543	0.1615	0.1592	0.0089	0.0097	0.0106	0.0120	0.0107
	11-53 days	0.1406	0.1441	0.1386	0.1394	0.1419	0.0083	0.0092	0.0087	0.0090	0.0100
	54-118 days	0.1344	0.1362	0.1354	0.1370	0.1352	0.0042	0.0046	0.0046	0.0046	0.0048
	119-252 days	0.1289	0.1276	0.1226	0.1289	0.1303	0.0033	0.0037	0.0034	0.0040	0.0037
	253+ days	0.3020	0.3834	0.4107	0.3671	0.3782	0.0156	0.0141	0.0148	0.0121	0.0154

Table 13: Non-trading length and delta-hedged excess option returns

This table reports the results of pooled regressions in which delta-hedged excess returns on various portfolios of equity options are regressed on three dummy variables. Dependent variables are the excess delta-hedged returns on portfolios formed on the basis of delta and maturity. Equal weighted (EW) portfolios weight all option contracts evenly, while value weighted (VW) portfolios weight contacts by the market value of their open interest. The first explanatory variable is a dummy that is equal to 1 if the return is computed over an interval that includes *any* non-trading period. The second is a dummy equal to 1 if the non-trading period is a mid-week holiday. The third dummy variable is set to 1 if the non-trading period is a long weekend of three or more days. The bottom of the table reports sums of some of the coefficients. Data are daily from January 4, 1996, through June 31, 2007. Standard errors are computed with clustering by date, and all regressions include portfolio fixed effects. T statistics are in parentheses.

	All options		Liquid subsample		S&P 100 stocks	
	EW	VW	EW	VW	EW	VW
Intercept	1.89	1.65	-1.91	-0.81	0.16	0.09
	(1.06)	(0.91)	(0.35)	(0.14)	(1.31)	(0.92)
Non-trading period dummy	-1.35	-0.86	-1.22	-0.82	-1.11	-0.87
	(10.24)	(6.27)	(7.70)	(4.85)	(11.15)	(7.47)
Mid-week holiday dummy	0.48	0.22	0.46	0.33	0.53	0.37
	(2.43)	(0.83)	(1.34)	(0.88)	(1.38)	(0.98)
Long weekend dummy	0.37	0.56	0.43	0.36	0.58	0.56
	(0.98)	(1.36)	(0.87)	(0.70)	(1.11)	(1.45)
Regression R-squared (in %)	0.48	0.46	0.98	0.99	1.13	0.96
Non-trading + mid-week	-0.87	-0.64	-0.76	-0.49	-0.57	-0.50
	(5.17)	(2.63)	(2.38)	(1.43)	(1.52)	(1.35)
Non-trading + long weekend	-0.98	-0.30	-0.79	-0.46	-0.53	-0.31
	(2.61)	(0.74)	(1.65)	(0.94)	(1.03)	(0.82)

Table 14: Explaining delta-hedged excess option returns, equal weighted portfolios

This table reports the results of pooled regressions in which the dependent variable is the delta-hedged excess return on various portfolios of equity options. The dependent and first three independent variables are described in Table 13. The next independent variable is a dummy that takes the value 1 if the return is computed over an option expiration weekend. Additional variables include the value-weighted average of lagged 5-day delta-hedged excess returns, the TED spread (Eurodollar minus T-bill yields), a 44-day rolling volatility computed from S&P 500 Index returns, and the VIX index. All of the latter variables are also interacted with the non-trading period dummy. Data are daily from January 4, 1996, through June 31, 2007. Standard errors are computed with clustering by date, and all regressions include portfolio fixed effects. T statistics are in parentheses.

Intercept	1.89	1.86	1.51	1.23	1.27	0.88	0.83	1.11
	(1.06)	(1.04)	(0.83)	(0.68)	(0.71)	(0.49)	(0.45)	(0.61)
Non-trading period dummy	-1.35	-1.23	-1.31	-0.62	-0.29	-0.29	0.16	-1.23
	(10.24)	(8.06)	(10.55)	(3.13)	(0.86)	(0.65)	(0.44)	(7.96)
Mid-week holiday dummy	0.48	0.37	0.58	0.48	0.50	0.48	0.51	0.56
	(2.43)	(1.73)	(3.14)	(2.36)	(2.52)	(2.42)	(2.53)	(2.68)
Long weekend dummy	0.37	0.35	0.46	0.37	0.30	0.33	0.39	0.48
	(0.98)	(0.92)	(1.20)	(0.97)	(0.78)	(0.85)	(0.99)	(1.25)
Expiration weekend dummy		-0.55					-0.56	-0.54
		(2.93)					(3.05)	(2.90)
Lagged 5-day DH return			0.24				0.22	0.20
			(8.41)				(8.09)	(8.62)
Lagged 5-day DH return × non-trading dummy			-0.14				-0.09	
			(2.48)				(1.62)	
TED spread				1.39			0.79	0.48
				(4.63)			(2.63)	(1.97)
TED spread × non-trading dummy				-1.78			-1.35	
				(3.56)			(2.87)	
44-day S&P 500 volatility					0.69		0.35	0.18
					(3.37)		(1.80)	(1.11)
44-day volatility × non-trading dummy					-1.00		-0.78	
					(3.27)		(2.73)	
VIX index						0.94		
						(6.12)		
VIX index × non-trading dummy						-0.84		
						(2.36)		
Regression R-squared (in %)	0.48	0.48	0.56	0.50	0.49	0.50	0.58	0.56

Table 15: Explaining delta-hedged excess option returns, value weighted portfolios

This table reports the results of pooled regressions in which the dependent variable is the delta-hedged excess return on various portfolios of equity options. The table is identical to Table 14 except that the dependent variable is now value weighted.

Intercept	1.65	1.59	1.56	1.08	1.28	0.96	0.92	1.15
	(0.91)	(0.88)	(0.85)	(0.59)	(0.71)	(0.52)	(0.50)	(0.63)
Non-trading period dummy	-0.86	-0.64	-0.87	-0.33	-0.04	-0.12	0.48	-0.64
	(6.27)	(4.02)	(6.25)	(1.42)	(0.10)	(0.24)	(1.13)	(4.04)
Mid-week holiday dummy	0.22	0.00	0.42	0.22	0.24	0.22	0.23	0.29
	(0.83)	(0.02)	(1.59)	(0.83)	(0.92)	(0.83)	(0.85)	(1.05)
Long weekend dummy	0.56	0.52	0.67	0.56	0.50	0.54	0.57	0.64
	(1.36)	(1.26)	(1.57)	(1.36)	(1.18)	(1.25)	(1.33)	(1.53)
Expiration weekend dummy		-1.09					-1.07	-1.04
		(5.34)					(5.37)	(5.10)
Lagged 5-day DH return			0.22				0.20	0.19
			(7.55)				(7.24)	(7.25)
Lagged 5-day DH return × non-trading dummy			-0.09				-0.06	
			(1.23)				(0.95)	
TED spread				1.18			0.81	0.58
				(3.92)			(2.91)	(2.55)
TED spread × non-trading dummy				-1.29			-1.02	
				(2.24)			(1.87)	
44-day S&P 500 volatility					0.40		0.21	0.07
					(2.78)		(1.63)	(0.57)
44-day volatility × non-trading dummy					-0.78		-0.67	
					(2.56)		(2.35)	
VIX index						0.65		
						(4.11)		
VIX index × non-trading dummy						-0.59		
						(1.46)		
Regression R-squared (in %)	0.46	0.47	0.53	0.48	0.47	0.48	0.57	0.56

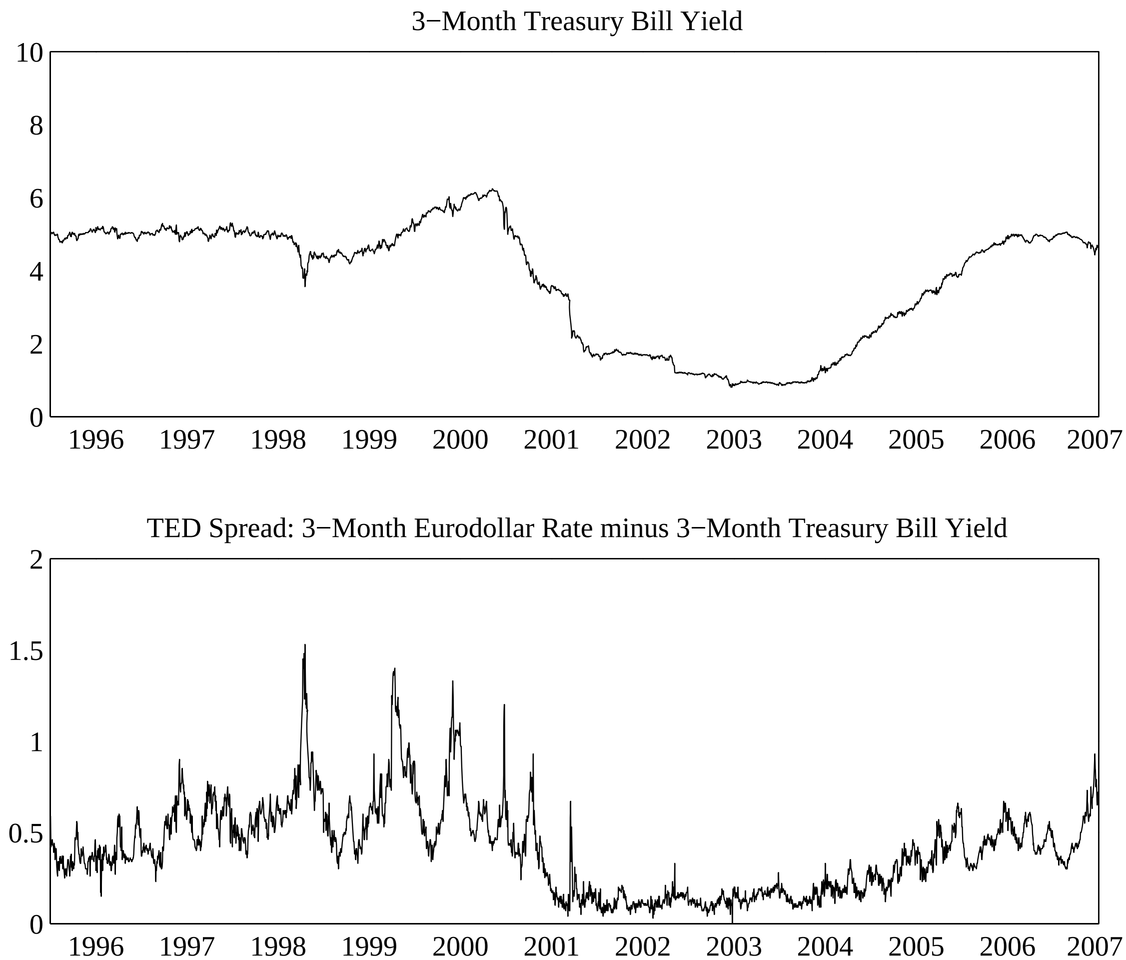

Figure 1: 3-Month Treasury Yield and TED Spread