Inattention in the Options Market

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ABSTRACT

Options on US equities typically expire on the third Friday of each month, which means that either four or five weeks elapse between two consecutive expiration dates. We find that options that are held from one expiration date to the next achieve significantly lower weekly adjusted returns when there are four weeks between expiration dates. We argue that this mispricing is due to investor inattention and provide further supporting evidence based on earnings announcement dates and price patterns closer to maturity. The results remain strongly significant controlling for a large set of option and stock characteristics, and are robust to various subsamples and estimation procedures. Our findings have potentially important implications for calibrating option pricing models as well as for extracting information from option prices to forecast future variables.

Keywords: Option returns; Investor inattention

JEL Classifications: G13, G14

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1. Introduction

Most options on US equities expire on the third Friday of each month. Due to calendar differences, the time between two consecutive expiration dates is either four or five weeks (four weeks in about 65% of all months and five weeks in the remaining 35%). The effect of an extra week on option value in this case can be 5 to 10% by Black-Scholes (1973) estimates. Yet most online option brokers do not show the number of days to expiration but rather only the year and month of maturity. An interesting question is therefore whether option traders pay full attention to the exact expiration date.

Imagine an investor who has to roll over her option position from one month to the next. She might have an underlying equity position that she hedges with puts, or wants to generate additional income through covered calls, or simply follows some month-to-month trading strategy. Either way, she is likely to reestablish her option position using options maturing next month as her current options approach expiration (or shortly after).

How does she price such options? Any formal model would naturally take into account the difference in maturities between four- and five-week options. However, any naive rule-of-thumb approach that treats all options similarly as "maturing next month" would fail to account for this difference. If enough investors price options simplistically as "maturing next month", this should cause option prices to diverge from fundamentals. In particular, such "naïve" investors would tend to underprice five-week options relative to four-week ones. (Keeping everything else equal, five-week options have greater time value, and thus should be more expensive than four-week options.)

It therefore appears that the natural calendar difference in maturities of one-month options provides a unique opportunity to test inattention in options markets. The direct implication of such inattention is straightforward: If four-week options are overpriced relative to five-week options, they should generate, on average, lower weekly adjusted returns. We provide evidence suggesting this might be the case.

Prior studies have documented that investors often appear inattentive to information that is relevant to stock value. For example, DellaVigna and Pollet (2009) find that investors are more likely to underreact to earnings announcements on a Friday than on other weekdays. They explain this by investor distraction as the weekend approaches. Another example is provided by

Hirshleifer, Lim, and Teoh (2009), who show weaker investor reaction to a firm's earnings announcement on days with many earnings announcements.[1]

The possible inattention to the exact number of days to expiration for short-term options goes beyond prior evidence on two fronts. First, option traders are assumed to be relatively sophisticated and more knowledgeable than average stock traders (trading options is more complex and entails more restrictions than trading stocks). Second, while firm-specific information embedded in financial statements or news releases requires some time and effort to process, the number of days to an option's expiration is very easy to obtain and requires simply one's attention. The fact that this information is not fully captured by option prices is quite puzzling and is indicative of a strong degree of behavioral investment.

To address this question, we look at the returns to one-month-maturity option positions (at-the-money straddles and delta-hedged calls and puts) established on the third Friday in a given month and held until their maturity on the third Friday in the following month. We choose the expiration day for the position formation because options on expiration days are highly traded due to the closing of the old positions. Our results show that these option strategies generate significantly lower returns when there are four weeks between the expiration dates than when there are five weeks. Straddle positions exhibit the largest difference, 2.6%, and delta-hedged calls and puts have differences of 0.5% and 0.4%, respectively, all highly significant at any conventional level.

To complement portfolio results with regression-based evidence, we run a pooled regression of average weekly returns to our option positions on a dummy variable for five-week maturity and a set of control variables that can affect option returns, as documented by prior literature. These control variables include the equivalent option position return on the S&P 500 index, the difference between implied and historical volatility, return skewness and kurtosis, firm size, book-to-market ratio, past stock return, idiosyncratic volatility, and others (see, e.g., Goyal and Saretto (2009) and Cao and Han (2013)). All regression specifications exhibit a significant positive effect of the five-week dummy on the option position return, consistent with the portfolio results. The results are robust to various subsamples and estimation procedures, including dynamic portfolio hedging.

[1] For more on investor inattention see also Hong, Torous, and Valkanov (2007), Cohen and Frazzini (2008), Chakrabarty and Moulton (2012), and Gilbert et al. (2012).

One might argue that four-week and five-week maturity options are not directly comparable, and that any difference in returns could be caused by the difference in maturity rather than mispricing. Note, however, that the hedged option returns are negative—if option positions are expected to lose value over time (on average), one would expect them to lose more value over a five-week period (as opposed to a four-week period), and hence expect to see lower returns on five-week option positions. Yet we find the opposite.

To further address this potential concern we implement the following test. For months with five weeks between expiration dates, we skip one week and establish our positions on the fourth Friday. These positions now have four weeks to maturity and can be compared to the original five-weeks-to-maturity positions for the same expiration date. Similarly, for months with four weeks between maturities, we step back one week and establish positions on the second Friday. Once again, such positions now have a five-week maturity and are comparable to the original four-weeks-to-maturity positions for the same expiration date. This exercise therefore allows us to compare the average returns on option positions with four and five weeks to maturity, while holding constant the number of weeks between the calendar expiration days (i.e., the source of inattention). The results of all positions show that options with five weeks to maturity gain on average a *lower return* than options with four weeks to maturity. This finding strengthens our argument: The relatively low return of options held for four weeks between expiration days may be driven by overpricing of these options compared to options held for five weeks between expiration days.

We next analyze whether the inattention-to-maturity effect is related to earnings news releases. Firms' earnings announcements usually attract a high volume of stock and option trading, as investors attempt to capitalize on the relatively sharp stock price movements around the announcement days.[2] This provides an opportunity to further examine the presence of inattention to the expiration day. First, investors who are motivated by earnings releases to trade options are less likely to pay attention to the exact expiration day, as they are likely to focus more on analyzing information in earnings. Second, earnings-based trades typically have short investment horizons (i.e., buying/selling assets around the announcement day), so such investors are less likely to hold

[2] See Ball and Brown (1968), Beaver (1968), May (1971), Morse (1981), Patell and Wolfson (1981, 1984), and McNichols and Manegold (1983) on the variability of stock prices around earnings announcements.

options until their expiration. We therefore expect that the difference between the option returns for four and five weeks between expiration days will be stronger for firms that release financial statements around the position formation day. Our results support this conjecture, providing further evidence for the presence of inattention in option trading.

Our tests also reveal that the difference between the returns on five-week and four-week options is larger for options that are more likely traded by retail investors, as measured by low short interest on the underlying security and violation of put-call parity. This finding is consistent with investor inattention to exact expiration dates, as retail investors are more subject to trading biases than professional investors.

Finally, we separate the position holding periods into two subperiods: from formation day until the end of the month, and from the end of the month until the expiration day in the next month. The reasoning is that as long as investors buy options that mature "in the next month" they are less likely to pay attention to the exact expiration date, whereas when buying options that mature "in this month" investors are more likely to look at the number of days to expiration. Investor inattention is therefore consistent with a stronger effect in the expiration month than in the formation month. We find strong support for this prediction.

Several recent studies have tried to detect mispricing in the options market. The common objective is to identify an option- or stock-specific characteristic that signals over- or underpricing in the cross-section of options, and can therefore predict subsequent returns. Goyal and Saretto (2009) show that a larger gap between implied volatility and historical volatility leads to higher option returns. Cao and Han (2013) show that option returns decrease monotonically with an increase in the idiosyncratic volatility of the underlying stock. Boyer and Vorkink (2014) find that the ex-ante skewness of options predicts negative option abnormal returns. Jones and Shemesh (2016) document a weekend effect in option prices that they attribute to the incorrect treatment of non-smoothness in stock return variance.

Our study is different insofar as we do not address individual option/stock signals, but rather show that an exogenous factor, common to all options—the number of weeks between consecutive expiration days—affects option returns in a significant systematic manner. Furthermore, the battery of tests that we perform suggest strongly that the mispricing of options we document is driven by investor inattention.

In addition to documenting evidence of investor inattention in the options markets, our paper has important implications for the option pricing literature. First, option pricing models do not account for the calendar month effect that we document, and are thus likely to result in pricing errors. In addition, using option prices to make predictions about future stock returns, return volatility, or equity betas, is subject to potential behavioral biases due to the relative mispricing of four- versus five-week options.

The paper proceeds as follows. Section 2 describes our data sources and construction of main variables. Section 3 presents the results from our main tests and performs robustness tests to provide additional evidence for the inattention mechanism we identify. Section 4 discusses potential implications of our findings for the option pricing literature. Section 5 concludes.

2. Data and variables

Our primary source of data is Ivy DB OptionMetrics which provides comprehensive coverage of US equity options from 1996 through 2014. OptionMetrics provides daily closing bid-ask quotes (as well as daily trading volume and open interest), and we compute our option portfolio returns from quote midpoints. We start by imposing certain filters on our option data. We remove options with zero open interest and options with zero trading volume, as such options are illiquid and their quotes are less likely to reflect any useful information. We retain only options maturing on the third Friday of a month. These are the standard American style US equity options.

In recent years options with weekly maturities have emerged for a limited number of stocks. Such options are less common and not well suited for testing our main hypothesis that relates to options with monthly maturities. We therefore exclude from our sample options that mature on a Friday but not the third Friday in a month and options maturing on any day other than Friday. The latter are more likely to be associated with errors in the data. We also eliminate observations that violate arbitrage bounds, observations for which the ask price is lower than the bid price, or the bid price is equal to zero. For each underlying security in each month, we pick a single call and a single put options, the ones that are closest to at-the-money.

We merge the option data with underlying equity data obtained from the CRSP dataset, using the matching algorithm provided by OptionMetrics. The resulting sample includes 264,802 call options (of which 170,125 have a four-week maturity and 94,677 have a five-week maturity) and 209,190 put options (135,434 with four-week maturity and 73,756 with five-week maturity). From these calls and puts we construct 157,407 straddles (101,842 with four-week maturity and 55,565 with five-week maturity). Each straddle portfolio contains a call and a put with the same strike price that is closest to the price of the underlying security on the portfolio formation date. In addition to straddles we also form delta-hedged call and put portfolios that combine an option position with holding negative delta units of the underlying security. This strategy implies adding a long (short) position in the underlying security for delta-hedged put (call) portfolios. We use deltas provided by OptionMetrics.[3] We include in the portfolios only options with moneyness (the ratio of the stock price to strike price) between 0.7 and 1.3. The results are robust to reasonable variations in the bounds on moneyness.

Table 1 presents summary statistics for our sample separately for calls and puts with four- and five-week maturities. We winsorize all variables at the 1st and 99th percentiles. Volume/open interest is the ratio of daily option trading volume of a given option contract to total open interest for the same contract (as of the end of the trading day). While the median ratio is about 0.13 for calls and 0.15 for puts, this variable is highly skewed due to a relatively small number of very heavily traded contracts resulting in much higher means (about 0.48 for calls and 0.57 for puts). This is a measure of liquidity of a given option contract. The second option liquidity measure that we use is the bid-ask spread, computed as the difference between the ask and bid quotes at the closing scaled by the midpoint quote. Neither volume/open interest ratio nor the bid-ask spread demonstrate any significant differences in liquidity of the option contracts with a five-week maturity versus those with a four-week maturity.

IV-HV is the difference between the option's implied volatility and historical volatility. Implied volatilities are provided by OptionMetrics. We compute historical volatilities based on daily returns over the last year. We construct this measure following Goyal and Saretto (2009), who show that it is a strong predictor of returns to option portfolios and might capture mispricing in the cross-section of equity options.

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[3] OptionMetrics uses a binomial tree model following Cox, Ross, and Rubinstein (1979) to calculate implied volatilities and other option greeks.

The other variables in Table 1 pertain to the characteristics of the underlying equity securities. We use these characteristics primarily as control variables in various regression specifications. Log(size) is the log of equity value of the underlying stock (in millions of dollars). Log(market-to-book) of the underlying stock is the ratio of current equity market value to equity book value as of the previous quarter. Past return of the underlying stock is cumulative return over the past six months. Illiquidity of the underlying stock is the Amihud's (2002) measure, calculated as the monthly average of daily ratios of absolute return to dollar trading volume (in millions). Skewness and kurtosis are based on the daily returns of the underlying stock over the previous month. Idiosyncratic volatility is measured by the standard deviation of the residuals of regression of daily stock returns on the daily Fama and French (1993) three factors over the previous month. Institutional ownership is the sum of all shares held by institutions divided by total shares outstanding. In constructing these measures we take the market variables from CRSP and the accounting variables from Compustat, where data on institutional ownership are obtained from Thomson Reuters.

For obvious reasons we focus only on optionable stocks that are typically larger, more liquid, and have more institutional ownership. For example, in our sample the median firm size is about 3.2 billion dollars, the median Amihud illiquidity measure is 0.06, and the median percentage of institutional ownership is about 73%. Still, there is reasonable variation in these characteristics across the firms in our sample (particularly for the Amihud illiquidity measure, with standard deviation between 0.66 and 0.88 for various subsamples in Table 1). Stocks in our sample also exhibit mildly positive skewness and kurtosis.

Note that implied volatilities of options with four-week maturities are higher than those of five-week options, both for calls and puts. For example, the mean implied volatility of four-week puts is 47.0%, while it is 44.6% for five-week puts. Although implied volatility is model-driven and therefore, by itself, is not a direct measure of potential mispricing, this difference can provide a first hint that four-week options are overpriced relative to five-week ones.[4]

Another way to gauge the degree of expensiveness of an option is to look at the difference between implied and historical volatilities (IV-HV). More volatile stocks are likely to have higher

[4] We recognize that option implied volatility exhibits a downward sloping term structure (see, e.g., Jones and Wang (2012)). Yet the mean difference between four- and five-week options' implied volatilities reported in Table 1 is too large to be explained by the slope of that term structure.

both historical and implied volatilities, so this difference might be a more accurate measure of the relative expensiveness of an option than the implied volatility itself. The differences between implied and historical volatilities of both calls and puts are higher for four-week options than for five-week ones. For example, the mean IV-HV difference for a four-week put is 3.9%, while it is only 2.4% for a five-week put. For calls the corresponding values are 2.9% and 1.5%.

This preliminary evidence suggests that the difference in number of weeks between consecutive option expiration dates can lead to mispricing of options. In the following sections we perform formal tests of this potential mispricing using both portfolio and regression based approaches.

As described above, we construct straddles and delta-hedged call and put portfolios. In our main tests we hold those portfolios unchanged until maturity of the options. In some of the robustness tests we rebalance the portfolios dynamically at weekly and daily frequencies. To calculate returns to our option portfolios we follow Goyal and Saretto (2009) and Cao and Han (2013). For straddles, we scale the total gain at expiration by the cost of constructing the straddle given by the sum of the prices of the call and the put at portfolio formation:

$$Straddle\ return = \frac{abs(ex\_sprc - strike)}{cprc + pprc} - 1 \qquad (1)$$

For delta-hedged call and put portfolios, we scale the total dollar gain at expiration by the total cost of constructing portfolios at the formation date given by the sum of the costs of the corresponding option and the hedge position in the underlying stock**:**

$$Delta - hedged\ call\ return = \frac{max(ex\_sprc - strike, 0) - cprc - \Delta(ex\_sprc - sprc)}{\Delta sprc - cprc} \qquad (2)$$

$$Delta - hedged\ put\ return = \frac{max(strike - ex\_sprc, 0) - pprc - \Delta(ex\_sprc - sprc)}{pprc - \Delta sprc} \qquad (3)$$

In equations (1)-(3) *sprc* is the price of the underlying stock at portfolio formation, *ex_sprc* is its price at expiration, *strike* is the option's strike price, *cprc* and *pprc* are the prices of the call and put options at portfolio formation, proxied by the midpoints of their bid and ask quotes, and Δ is the option's delta, provided by OptionMetrics.

3. Empirical tests

3.1 A first look at the differences in option prices – portfolio returns

Our main conjecture is about investor inattention to exact option maturity dates and the potential mispricing of options resulting from this inattention. The natural difference in the number of weeks between two consecutive maturity dates provides a perfect opportunity to dissect the effects of potential inattention.

We therefore form our option portfolios on the third Friday of each calendar month using options that mature next month and hold these portfolios until maturity (on the third Friday of the next month). We have noted that the time between two consecutive expiration dates is either four or five weeks (four weeks in about 65% of all months and five weeks in the remaining 35%).

We choose the expiration day for the position formation because there is a lot of trading in options on expiration days, with the closing of the old positions and opening of the new ones. It is likely that investors who routinely follow certain option strategies (e.g., buying protective puts or writing covered calls) need to roll their positions forward around expiration dates when their current options positions expire. In robustness tests below, we follow an alternative portfolio formation strategy and establish our option positions on the last trading day in a month. This alternative procedure yields results that are consistent with our main hypothesis.

How does potential investor inattention transpire into option prices? If enough investors price options simplistically as "maturing next month" and ignore the exact number of days to maturity, this should cause a deviation of option prices from fundamentals. That is, such "naïve" investors would tend to underprice five-week options relative to four-week ones.

Our very first test is therefore designed to capture any potential difference in returns to our option portfolios (straddles and delta-hedged calls and puts) with four- and five-week maturities. To perform this test we compute the average returns on all three types of portfolios separately for the two maturities. The results are reported in Table 2. First, all portfolio average returns are negative. This is consistent with the findings of Bakshi and Kapadia (2003), Goyal and Saretto

(2009), and Cao and Han (2013). Average straddle returns are the most negative (-7.6% and -5.02% for four- and five-week maturities, respectively), followed by delta-hedged calls (-1.09% and -0.6%), and then delta-hedged puts (-0.87% and -0.48%). The straddle returns appear higher in magnitude due to the different scaling applied when computing percentage returns. As shown in equations (1)-(3), we scale straddle dollar returns by the sum of the put and call prices, while the delta-hedged portfolio returns by the sum of the price of the option and the price of delta units of the underlying security. Option prices are typically substantially lower than the prices of underlying equity, resulting in higher absolute values of straddle returns.

More important, the results in Table 2 show that all three portfolio types underperform in four-week months relative to five-week months. The effect is again strongest for straddle portfolios (-2.58% difference), followed by delta-hedged calls (-0.49%) and delta-hedged puts (-0.39%). These results are consistent with our main hypothesis on inattention, and provide the first piece of evidence showing relative overpricing of four-week options. Note that keeping everything else equal, five-week options have greater time value. Given generally negative returns to our option portfolios, one might conjecture that five-week options have more time to lose their value and therefore produce lower returns. Our evidence, however, suggests the opposite.

To better visualize the extent of the four- versus five-week maturity effect, we consider the following trading strategies. The four-week strategy shorts delta-hedged call and put portfolios on all optionable stocks in our sample (and takes equally weighted positions in those portfolios) on option expiration dates in months with four weeks to the next expiration date. The five-week strategy does the same in months with five weeks to the next expiration date. The cumulative performance of these strategies is presented in Figure 1, which clearly demonstrates the superiority of the four-week strategy. Its total return over our sample period from January 1996 through September 2014 is over 400% for short delta-hedged calls and over 250% for short delta-hedged puts. The corresponding cumulative returns for the five-week strategy are merely 52% and 33% for short delta-hedged calls and puts, respectively.

While it is useful for identifying the pricing effect in the data, the simple *t*-test in Table 2 suffers from a number of limitations. First, it does not account for potential correlation in portfolio returns for different securities on a given date. Option portfolios may be positively correlated when the underlying equity securities are also correlated (with each other and also with the market portfolio). In that case, a large move of the market in any direction will likely lead to low straddle returns as well as lower returns to either delta-hedged put or call portfolios (depending on the direction of the move). Moreover, an unexpected change in market volatility or general economic uncertainty is likely to simultaneously affect option prices across various securities. Thus, the high *t*-statistics in Table 2 that range from 6.66 for straddles to over 11 for delta-hedged calls should be taken with a grain of caution.

Furthermore, the test in Table 2 does not allow us to control for various determinants of option returns documented in the literature. Finally, comparing four-week portfolio returns with five-week returns might itself not be a fair experiment. It is probably more appropriate to express both returns in the same terms (e.g., convert both to weekly returns) before comparing. We address all these issues in the next subsection.

3.2 Regression based evidence

We perform a multivariate analysis of the determinants of returns to our option portfolios and the effect of option maturity on potential mispricing, while controlling for potential cross-sectional correlation of option returns on a given date. The empirical specifications and estimation results are presented in Table 3.

First, we convert all portfolio returns to weekly terms to make them directly comparable for options with different maturities. To do so, we divide returns in months with five weeks between consecutive maturity dates by five, and divide returns in four-week months by four. Second, we cluster standard errors by date to account for cross-sectional correlation of residuals. Specification (1) includes a 5-week dummy, which we set to one for options with a five-week maturity and to zero for options with a four-week maturity. According to our main inattention hypothesis, we expect investors to overprice four-week options relative to five-week ones, and therefore expect a positive coefficient on the 5-week dummy**.** The coefficient of this specification represents therefore the difference in the raw average returns of the five- and four-week option portfolios; and note that this coefficient should be lower than the return difference appears in Table 2 as it is in weekly terms.

In specification (2) we add the equivalent option-position return on the S&P 500 index as a control variable. This is the return from a similar option portfolio (straddle, delta-hedged put, or delta-hedged call) constructed from S&P 500 options (and using the underlying S&P 500 index as a hedge for delta-hedged calls and puts). As we argue above, large market returns are likely to affect all returns on our option portfolios for different securities and therefore inflate their volatility. As large market movements can occur in either four- or five-week months, and do not appear to bear any relation with investor inattention, we attempt to mitigate their effect by including the S&P 500 portfolio returns as a control.

In specification (3) we follow other papers that analyze option returns (see, for example, Goyal and Saretto (2009) and Cao and Han (2013)), and add option-specific characteristics that can potentially affect option returns as control variables. We use two measures of option liquidity–the ratio of option trading volume to open interest, and the option bid-ask spread. We also include the difference between option implied volatility and the historical volatility of the underlying stock, following Goyal and Saretto (2009) who document that this variable is a strong predictor in the cross-section of option returns.

In specification (4) we also add various characteristics of the underlying equity. We follow Brennan, Chordia, and Subrahmanyam (1998) and Goyal and Saretto (2009) and add (log) firm size, (log) market-to-book ratio, and past stock return as well as measures of the skewness and kurtosis of underlying equity returns, defined as before; and we follow Cao and Han (2013) and add idiosyncratic volatility. In addition, we add a stock illiquidity measure, based on Amihud (2002).

A first glance at the results in Table 3 reveals a striking difference between the *t*-statistics on the 5-week dummy in regression specifications (1) in Table 3 and on the return differences in Table 2. Without controls, all the coefficients in specification (1) (for straddles, delta-hedged calls, and delta-hedged puts) are now insignificant (although still high in magnitude). This confirms our conjecture about high cross-sectional correlation between returns to our option portfolios. In specifications with appropriate controls, however, coefficients on the 5-week dummy become highly statistically significant (at a 5% level for delta-hedged calls and puts and at a 1% level for straddles). Most of the improvement in significance comes from inclusion of the corresponding return on the S&P 500 option portfolios, which eliminates some of the residual variation unrelated to investor inattention and maturity of the option portfolios, thus improving significance.

Among the other control variables, the difference between implied and historical volatilities, firm size, market-to-book ratio, and illiquidity of the underlying equity as well as its kurtosis are significant. Consistent with the findings of Goyal and Saretto (2009), IV-HV is negatively related to option returns, and most strongly for delta-hedged call and put portfolios. And consistent with Cao and Han (2013), idiosyncratic volatility is negatively related to delta-hedged option returns. The market-to-book ratio affects returns negatively, especially for delta-hedged calls and puts, suggesting that options on more highly capitalized firms with fewer investment opportunities tend to have higher returns on average. The economic magnitude of this effect is however small: An increase in market-to-book by one standard deviation leads to a 0.028% decrease in delta-hedged call returns and a 0.033% decrease in delta-hedged put returns.

Amihud's (2002) measure of stock illiquidity is negative and highly significant in our regressions of option returns. Options on more thinly traded stocks seem to offer lower returns. To our knowledge this is a new effect that has not been previously documented in the literature. Options' own liquidity shows mixed results, as volume/open interest does not have an effect on option returns, while option bid-ask spread has a negative effect in some of the specifications. This is consistent with the idea that investors in options markets demand additional compensation for holding illiquid option positions as long as they have net short options positions. Note that Lakonishok et al. (2007) find that non-market maker investors in aggregate have more written than purchased options. Consistent with Goyal and Saretto (2009), we find that the underlying stock's kurtosis has a negative effect on option returns.

Overall, the results in Table 3 provide strong support for our main hypothesis of investor inattention and its effect on option returns. Coefficients on the 5-week dummy are highly significant in all specifications with appropriate controls. In the subsequent analysis we perform further tests to tease out the role of inattention.

3.3 Additional tests

We continue with various robustness tests documented in Table 4. We report the robustness of specifications (2) and (4) from Table 3; the other specifications show similar results. In the first test we exclude large changes in aggregate market uncertainty, defined as months when VIX moved by more than 5% in any direction between option expiration days. Such observations represent about 20% of the sample, with the most extreme VIX movement of 38% occurring between the expiration days in September and October 2008. As there is no foreseeable correlation between time between expiration dates and unexpected aggregate volatility changes as measured by VIX, observations corresponding to extreme changes in VIX add extra noise to our portfolio returns. We therefore expect that excluding such cases should amplify the significance of our four- versus five-week maturity effect. Indeed, as results in Table 4 demonstrate, excluding observations with extreme VIX movements improves significance in all regression specifications and for all types of option portfolios. The *t*-statistics on the 5-week dummy are now consistently above 3 and range from 3.22 in specification (4) for delta-hedged calls to 3.70 in specification (2) for straddles.

Following a similar logic, we repeat our analysis while excluding recession months based on the NBER recession classification. Recessions typically correspond to large and unpredictable market movements and therefore might blur the maturity effect that we identify. Consistent with this conjecture, excluding recession months also raises the *t*-statistics on the 5-week dummy across all specifications and portfolio strategies, although to a somewhat lesser extent than excluding months with extreme VIX movements.

In the next robustness test we narrow the bounds that we impose on option moneyness at the time of portfolio formation. In particular, we restrict our analysis to options with moneyness between 0.95 and 1.05 (in our original tests the bounds on the moneyness are 0.7 and 1.3). As shown in Table 4, this exercise keeps the results essentially unchanged, in terms of both regression coefficients and their significance.

We also exclude new optionality stocks (those stocks with options listed within one year prior to portfolio formation) as well as add calendar month fixed effects. None of these adjustments has any material effect on our results. Finally, we introduce dynamic rebalancing of our delta-hedged call and put portfolios at weekly and daily frequencies. That is, at any rebalancing date we bring our portfolios back to delta-neutrality by changing the weight in the underlying security to offset the delta of the corresponding option that might change between rebalancing dates. Interestingly, this procedure leads to higher coefficients on the 5-week dummy for delta-hedged puts, but to somewhat lower coefficients for delta-hedged calls. The coefficients remain statistically significant for most specifications.

Our next test is related to potential concerns about comparing returns to four-week options with those to five-week ones in Table 1. One might potentially argue that options with different maturities are fundamentally different, and their returns therefore are not directly comparable. Note that it would still be hard to come up with a reasonable explanation for why returns to five-week options are higher than returns to four-week ones; we find negative returns for all the option portfolios, and five-week options have more time to realize those returns, so intuitively, absent any behavioral effect, one would expect lower, not higher returns to five-week options (unless there is some unusual time variation in returns).

To further alleviate this concern, we perform the following test. For every expiration date in our sample, we step back either four or five weeks, and form our portfolios. This procedure implies that some portfolios are formed exactly on the expiration date in the previous month, some are formed one week before, and some one week after. We then compare returns to these four-week and five-week portfolios. The results are summarized in Table 5. Here we convert portfolio returns to weekly terms, by dividing corresponding holding-period returns by four or five, depending on the maturity. (So, for example, the -1.90% and -1.00% weekly straddle returns in Table 5 correspond to -7.60% and -5.02% monthly returns in Table 2). The evidence in Table 5 is in striking contrast to that in Table 2. When we keep the expiration date constant and therefore remove the potential inattention effect, the difference between five-week and four-week option returns flips in sign from positive to negative. This effect is uniform across all our option portfolios – straddles as well as delta-hedged calls and puts.

The results in Table 5 suggest therefore that, on average, options with five weeks to maturity gain lower return than options with four weeks to maturity. Thus, our finding on the over-performance of options during months with five weeks versus four weeks between expiration days is not driven by the general effect of time to maturity on option returns, which strengthens the investor inattention argument.

3.4 Additional inattention proxies

Our findings so far document a bias in option prices related to the timing of the consecutive option maturity dates that we conjecture is due to investors' inattention to exact option expiration dates.

To provide further evidence that this effect is driven by inattention, we examine how the strength of this effect varies with variables that are likely to proxy for the degree of inattention.

We use three such proxies. The first one is institutional ownership of the underlying equity security. While this factor is not a direct proxy for the sophistication of option traders, one might envision that options on stocks with higher institutional ownership are also traded more actively by institutions, and we would therefore expect less room for any behavioral biases in their pricing.

Our second inattention proxy is the proximity of earnings announcement dates. There are two reasons to include this proxy. First, consistent with some findings in the literature, investor attention might be blurred on or around earnings announcement as investors process the information in earnings and react to it. For example, DellaVigna and Pollet (2009) find that investors are more likely to underreact to earnings announcements on a Friday than on other weekdays; they explain this by added investor distraction as the weekend approaches. Another example is provided by Hirshleifer, Lim, and Teoh (2009) who show that investor reaction to a firm's earnings announcement is weaker on days with many earnings announcements. We therefore expect the option mispricing effect to be stronger when option portfolios are formed on days close to announcement dates. Second, many option traders follow short-term trading strategies around earnings announcements (e.g., buying options shortly before the announcement and selling shortly after). Due to the short-term nature of such strategies, option traders are less likely to pay attention to the exact option maturity dates, again potentially amplifying our effect. We use three different time windows to capture the potential effect of earnings announcements – three, five, and seven trading days around announcements. All earnings announcement dates are obtained from IBES. There are 77,062 firm-months with earnings announcements in our samples.

Our third and last proxy for inattention is merger announcements. While there are many fewer mergers than earnings announcements, merger announcements can potentially lead to a similar effect – first, investors might be occupied primarily with analysis of the information in the announcement. Second, following some short-term option strategies around announcement days might make investors less attentive to exact maturity dates. Note, however, that unlike earnings dates, merger announcements are typically not known in advance, which limits the potential scope for short-term trading around merger announcements. A more common "merger arbitrage" strategy is to trade the acquirer and target stocks and/or options on those stocks shortly after the announcement and hold these portfolios until merger consummation. These strategies are generally longer term, as it usually takes months for a merger to be completed, and traders following such strategies are therefore more likely to pay attention to option maturity dates. We therefore expect stronger results for earnings versus merger announcements. As with earnings, we use three different time windows for merger announcements – three, five, and seven trading days. We obtain merger announcement data from SDC Platinum. Merging it with our options data produces 16,331 merger announcement dates that we use in our analysis.

To test for the effects of our three inattention proxies, we run pooled regressions as in model (4) in Table 3 while adding these proxies as well as their interaction terms with the 5-week maturity dummy to our regression specifications. We are primarily interested in coefficients on the interaction terms. We expect a weaker effect for stocks with high institutional ownership, and stronger effects for earnings and merger announcements. Also, for the reasons discussed above, we expect the earnings effect to dominate the merger effect.

The results in Table 6 confirm our hypothesis. The coefficient on the interaction term of the 5-week dummy and a dummy for earnings announcement window is positive and highly significant across all portfolio strategies. While it is significant for all three windows, its strength declines with the length of the window. For example, in the case of straddle portfolios, the interaction coefficient goes down from 1.793 (with a *t*-statistic of 2.99) for the three day window to 1.003 (a *t*-statistic of 2.13) for the seven day window. A similar pattern is observed in interaction coefficients for delta-hedged calls and puts. These patterns further demonstrate the importance of proximity to the announcement date. The economic effect of earnings announcements on portfolio returns is huge. For straddle returns, the difference between five- and four-week portfolio returns if formed within three days around earnings announcements is 3.05% per week (versus 1.26% for the whole sample). For delta-hedged calls and puts this difference goes up from 0.14% to 0.46% and from 0.11% to 0.33% respectively.

Coefficients on interaction terms with institutional ownership and merger announcement dummy, while having the expected signs, are statistically insignificant. This finding is not too surprising, given that institutional ownership of underlying equity is not necessarily a perfect proxy for the sophistication of investors in options on this equity security. On the other hand, merger announcements are subject to the potential concerns discussed above (many fewer observations and the infeasibility of short-term trading strategies around the unpredictable announcement dates).

3.5 Effect of investor type

As discussed above, option traders are assumed to be relatively sophisticated and more knowledgeable than average stock traders. Yet we can classify option traders into different levels of professionalism (see Lakonishok et al. (2007) for a detailed analysis of options investor types). Conventional wisdom would suggest that retail investors are more likely to be inattentive to relevant information than more sophisticated investors, such as market makers, hedge funds, or large corporations. We examine whether the evidence of investor inattention to the number of weeks to expiration is weakening with a rise in trader sophistication.

We use two proxies for options investor type. The first is the extent of short interest on the underlying stock. First, professional investors are more likely to short stocks than retail investors. Thus if there is high short interest on specific stocks, those sophisticated investors might see problems locating shares to short and can go to the options market instead. In addition, market makers/professional investors tend to trade options on stocks with high short interest due to their hedging activity (see, for example, Figlewski and Webb (1993) and Evans et al. (2009)). We measure the extent of short interest for each option position by the log of the ratio of short interest on the underlying stock to common shares outstanding as of the 15th of the formation month (obtained from Compustat).

The second proxy for investor type is violation of put-call parity. Such violations are typically caused by unusual levels of demand or supply by investors who speculate on the future movement of the underlying stock price. Because unsophisticated options traders tend to speculate more than professional investors (see, for example, Lakonishok et al. (2007), Mahani and Poteshman (2008), and Lemmon, and Ni (2013)), we expect a stronger inattention effect for options with larger deviations from put-call parity. We follow prior studies and measure deviation from put-call parity by the absolute difference between the implied volatilities of call and put options on the same underlying stock, and with the same strike price and the same expiration date (see Figlewski and Webb (1993), Amin, Coval, and Seyhun (2004), and Cremers and Weinbaum (2010), among others). For the purpose of our study we use the average of the implied volatility spread of at-the-money options across the different maturities.

Table 7 shows the results of pooled regressions as in model (4) in Table 3 while adding short interest and put-call parity deviation as well as their interaction terms with the 5-week maturity dummy. Short interest has a significant negative effect for all option positions; the *t*-statistics of the interaction term coefficient are between -2.20 and -2.69. This confirms our conjecture that most sophisticated investors are more likely to incorporate into pricing the options' exact expiration dates. The effect of put-call parity violation provides somewhat weaker support to this conjecture as the coefficient of the interaction variable is always in the predicted sign, yet statistically insignificant (*t*-statistics between 1.04 and 1.73).

3.6 The dynamics of mispricing and alternative portfolio formation dates

In our main tests we establish our option positions on the expiration date (the third Friday) in a month and hold them until the next expiration date. The holding period thus spans both the remainder of the current month as well as the period prior to the third Friday in the next month. Our evidence so far shows overpricing of four-week options relative to five-week options. An interesting question is then when this overpricing is corrected. In particular, does the correction occur in the current (portfolio formation) month or in the next (expiration) month?

We argue that the mispricing we identify is driven by investor inattention to the options' exact maturity dates and naive treatment of options as "maturing next month". If this is true, one should expect to see the correction of mispricing occur more in the expiration month. Once in that month, investors can no longer consider all options similarly as "maturing next month" and must start to pay more attention to the exact number of days to maturity.

We formally test for the dynamics of mispricing as follows. We first divide the total return of each of the three option portfolios (straddles and delta-hedged calls and puts) into two periods: the return from the option formation day until the end of the month, and the return from the end of the month until the expiration day in the next month. We convert each return to weekly terms by first dividing it by the number of trading days in the corresponding month and then multiplying by seven, to make any regression coefficient directly comparable with those in our main tests. We then regress each return (in weekly terms) on the 5-week dummy variable and the equivalent option-position return on the S&P 500 index (as in the second regression specification in Table 3), and on both option and stock characteristics (as in the fourth regression specification in Table 3). As in all our regression tests, we cluster standard errors by date. The results are presented in Figure 2. To conserve space, this figure shows only the coefficients of the 5-week dummy variable (multiplied by 100).

Analysis of the results in Figure 2 reveals an interesting pattern that is consistent with our conjecture. For all three portfolio types, the coefficients on the five-week dummy are substantially higher. The corresponding one-tail *p*-value across all portfolios and models ranges from 0.013 to 0.204. The effect is particularly strong for delta-hedged calls, when all of the adjustment occurs in the expiration month. Similar, although less extreme patterns are observed for delta-hedged puts and straddles. For delta-hedged puts, coefficients on the 5-week dummy in expiration months are roughly 2.5 times higher than those in formation months. For straddles, the difference in coefficients is roughly three times.

Overall, the evidence in Figure 2 shows that most of the mispricing adjustment takes place in expiration months, when the naïve approach of treating all options maturing next month as having roughly similar ("next month") maturity is no longer applicable. This evidence provides additional support to our hypothesis that the relative mispricing of four- and five-week options is driven by investors' inattention to the exact maturity date.

In our final test, we consider alternative portfolio formation dates. In our main tests we form our portfolios on the expiration day because options on expiration days are highly traded due to the closing of the old positions and opening of the new ones, and also because we expect investors who routinely follow certain option strategies to roll their positions forward around expiration dates when their current option positions expire. However, if the results are driven by investor inattention to maturity dates, resulting in treating all next-month options as having roughly similar maturity, then a similar effect should materialize if we form our portfolios on a different date, as long as it is in a month preceding that of the expiration date of the options.

We thus repeat our analysis while forming our option positions on the last trading day in a calendar month (rather than the third Friday) and hold them again until they mature on the third Friday in the next month. Since the four- and five-week time frame no longer applies, we use the number of days to expiration in our regressions instead of the 5-week dummy. As before, we first convert portfolio returns to weekly terms to make the results directly comparable. We then run pooled regressions of the resulting weekly returns from the end of the month until the expiration day in the next month on the number of days until expiration. We follow exactly the regression specifications in Table 2 and use the same control variables. If investors are inattentive to the options' exact expiration dates, they will naturally overprice options with shorter maturities and underprice options with longer maturities. This should result in higher average weekly returns to options with more days to expiration, so the regression coefficients on the number of days to expiration are expected to be positive.

The regression results are presented in Table 8. The results are strongly supportive of the inattention hypothesis. The coefficients on the number of days to expiration are positive and highly significant in most specifications (with the exception of specification (1) that does not include any controls). The *t*-statistics are generally higher than those in Table 3, and all coefficients on days to expiration in specifications (2), (3), and (4) are now significant at a 1% level.

Overall, the timing pattern in our option portfolio returns as well as results for alternative portfolio formation dates provide strong additional support for the inattention conjecture.

4. Implications for option pricing literature

The evidence reported in this paper suggests that there is a "mispricing" factor for short-term options, which is generated by the fact that there are either four or five weeks between two consecutive expiration dates. This finding has potentially important implications for both the pricing of traded options as well as using option prices to predict future variables like stock returns or return volatility.

On the one hand, option pricing models that do not account for the effect of the number of weeks between expiration dates (and to the best of our knowledge, there are no existing option pricing models that would incorporate this effect), but are rather calibrated on the pool of options that includes both four- and five-week options, are likely to result in pricing errors. This applies to the whole spectrum of option pricing models, from that of Black and Scholes (1973) to more advanced ones like Heston (1993), Pan (2002), Bakshi, Kapadia, and Madan (2003), Christoffersen, Heston, and Jacobs (2013), and Geske, Subrahmanyam, and Zhou (2016), among others.

On the other hand, if option prices are used to predict some forward-looking information, the accuracy of such forecasts is likely to depend on whether they are based on four- versus five-week options. For example, An et al. (2014) document a relation between changes in call (put) implied volatilities and subsequent stock returns; Bali and Hovakimian (2009) examine the predictive ability of the difference between implied and realized volatilities; Xing, Zhang, and Zhao (2010) study the effect of risk-neutral skewness; and Chang et al. (2012) use option prices to extract forward-looking equity betas. Our findings suggest that the prices of options and hence their implied volatilities might be sensitive to the calendar month effect that we document. Furthermore, as five-week maturity periods tend to alternate with four-week ones, this might give rise to a certain autocorrelation process in implied volatilities. It is potentially interesting to examine how the results in the above studies vary with the choice of four- versus five-week options.

5. Conclusions

We document a strong mispricing effect in options markets. Options that are held from one expiration date to the next achieve significantly lower weekly adjusted returns when there are four weeks between expiration dates than when there are five weeks. Mispricing is stronger if option portfolios are formed around earnings announcement dates. The mispricing is corrected mostly in the month following the portfolio formation month. Weekly returns to option portfolios formed on the last trading date of the month exhibit a strong positive relation to number of days to maturity. The results remain strongly significant controlling for a large set of option and stock characteristics, and are robust to various subsamples and estimation procedures.

All this evidence strongly suggests that the effect we identify in the data is driven primarily by investor inattention to the exact number of days to expiration and by a tendency to treat options maturing in the next month as having similar "next month" maturity. This evidence is strikingly puzzling for two reasons. First, option traders are assumed to be relatively sophisticated and more knowledgeable than retail stock traders (trading options entails more restrictions than trading stocks, and most retail brokers require some trading experience before granting option trading permission). Our tests indeed show evidence of a stronger mispricing for options that are more likely traded by retail investors. Second, while firm-specific information embedded in financial statements or in news releases requires some time and effort to process, the number of days to an option's expiration is very easy to obtain; it requires attention alone. The fact that this information is not fully captured by option prices is indicative of a strong degree of behavioral investment in the options markets.

Our findings also have important implications for the option pricing literature. That is, calibrating option pricing models without accounting for the calendar month effect that we document is likely to result in pricing errors. Moreover, using option prices to make predictions about future stock returns, return volatility, or equity betas, is subject to potential behavioral biases due to the relative mispricing of four- versus five-week options.

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Table 1. Summary statistics

The data on options are from the OptionMetrics Ivy DB database over the period 1996 to 2014. Data on the underlying stocks are obtained from CRSP/Compustat. The sample includes data on all options as of the option expiration day in each month, i.e., the third Friday of each month. The selected options are those that expire in the following month. For each underlying security in each month, we pick the call and the put options that are closest to at the money. We include only options with moneyness (ratio of stock price to strike price) between 0.7 and 1.3, and we exclude options with zero open interest or trading volume. The table reports statistics of the characteristics of the options as well as their underlying stocks. All variables are winsorized at the 1st and 99th percentiles. Volume/open interest is the ratio of the daily trading volume to open interest of the option. Option bid-ask spread is the difference between the ask and bid quotes of the option over the midpoint of bid and ask quotes at the end of the day. Implied volatilities are provided by OptionMetrics. IV-HV is the difference between the option's implied volatility and historical volatility, based on daily returns over the last year. Log(size) is the log of equity value of the underlying stock (in millions of dollars). Log(market-to-book) of the underlying stock is the ratio of current equity market value to equity book value as of the previous quarter. Past return of the underlying stock is cumulative return over the past six months. Illiquidity of the underlying stock is the Amihud's (2002) measure, calculated by the monthly average of daily ratios of absolute return to dollar trading volume (in millions). Skewness and kurtosis are based on the daily returns of the underlying stock over the previous month. Idiosyncratic volatility is the standard deviation of the residuals of regression of daily stock returns on the daily Fama and French (1993) three factors over the previous month. Institutional ownership is the sum of all shares held by institutions divided by total shares outstanding.

	Calls						Puts					
	4-week maturity # obs = 170,125			5-week maturity # obs = 94,677			4-week maturity # obs = 135,434			5-week maturity # obs = 73,756		
	Mean	Median	Stdev	Mean	Median	Stdev	Mean	Median	Stdev	Mean	Median	Stdev
Volume/open interest	0.487	0.133	1.274	0.479	0.132	1.259	0.579	0.155	1.437	0.567	0.152	1.408
Option bid-ask spread	0.192	0.127	0.234	0.182	0.122	0.221	0.174	0.118	0.210	0.163	0.111	0.196
Implied volatility	0.461	0.404	0.244	0.439	0.387	0.230	0.470	0.412	0.249	0.446	0.392	0.235
IV-HV	0.029	0.035	0.154	0.015	0.025	0.148	0.039	0.043	0.154	0.024	0.033	0.147
Log(size)	14.875	14.769	1.585	14.852	14.746	1.593	15.082	14.985	1.581	15.076	14.985	1.592
Log(market-to-book)	1.101	1.036	0.855	1.084	1.020	0.845	1.105	1.044	0.866	1.093	1.032	0.862
Past stock return	0.115	0.073	0.417	0.110	0.066	0.400	0.107	0.064	0.413	0.103	0.059	0.397
Stock illiquidity	0.310	0.063	0.848	0.320	0.064	0.880	0.223	0.048	0.642	0.228	0.048	0.655
Skewness	0.174	0.156	0.920	0.144	0.125	0.948	0.151	0.142	0.927	0.114	0.104	0.947
Kurtosis	1.131	0.315	2.646	1.231	0.364	2.784	1.132	0.306	2.670	1.216	0.349	2.775
Idiosyncratic volatility	0.020	0.016	0.015	0.020	0.016	0.014	0.020	0.016	0.014	0.020	0.016	0.014
Institutional ownership	0.705	0.735	0.223	0.705	0.735	0.222	0.716	0.745	0.217	0.713	0.741	0.217

Table 2. Option returns for 4- and 5-week maturities

The data on options are from the OptionMetrics Ivy DB database over the period 1996 to 2014. Data on the underlying stocks are obtained from CRSP/Compustat. The sample includes data on all options as of the option expiration day in each month, i.e., the third Friday of each month. The selected options are those that expire in the following month. For each stock we select a single option every month, the one with moneyness closest to 1, as long as it is between 0.7 and 1.3. We exclude options with zero open interest or trading volume. The table reports average returns on three option positions for options with four and five weeks to maturity. Returns on all positions are based on market prices at option expiration day in a month and the position's payoff at the option maturity day in the next month. The positions are straddles, delta-hedged calls, and delta-hedged puts. Returns are given by:

$$Straddle\ return = \frac{abs(ex\_sprc - strike)}{cprc + pprc} - 1$$

$$Delta - hedged\ call\ return = \frac{max(ex\_sprc - strike, 0) - cprc - \Delta(ex\_sprc - sprc)}{\Delta sprc - cprc}$$

$$Delta - hedged\ put\ return = \frac{max(strike - ex\_sprc, 0) - pprc - \Delta(ex\_sprc - sprc)}{pprc - \Delta sprc}$$

where *ex_sprc* is the price of the underlying stock at expiration, *strike* is the option's strike price, *cprc* and *pprc* are the prices of the call and put options at purchase day, given by the midpoints of their respective bid and ask quotes, and Δ is the option's delta. The table also reports the differences between the four- and five-week position returns and their *t*-statistics.

	Straddles		Delta-hedged calls		Delta-hedged puts	
	# obs	avg return	# obs	avg return	# obs	avg return
4 weeks	101,842	-7.60%	170,125	-1.09%	135,434	-0.87%
5 weeks	55,565	-5.02%	94,677	-0.60%	73,756	-0.48%
difference		-2.58%		-0.49%		-0.39%
t-statistic		(-6.66)		(-11.15)		(-9.26)

Table 3. Regression of option returns on 4-5 week maturity and option/stock characteristics

We run a pooled regression of the average weekly returns of the three option positions described in Table 2 on a dummy variable that equals one if the option matures in five weeks, and zero if the option matures in four weeks. The control variables include the equivalent option-position return on the S&P 500 index (SPX), and both option characteristics (volume/open interest, bid-ask spread, and IV-HV) and stock characteristics (log(size), log(market-to-book), past stock return, stock illiquidity, return skewness, return kurtosis, and idiosyncratic volatility) as described in Table 1. All coefficients are multiplied by 100, and *t*-statistics are in parentheses, where standard errors are clustered by date. The sample period is 1996 to 2014.

	Straddles				Delta-hedged calls				Delta-hedged puts			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept	-1.899	-1.732	-1.763	-2.004	-0.272	-0.199	-0.154	-0.116	-0.218	-0.167	-0.106	0.106
	(-3.82)	(-6.18)	(-6.08)	(-1.55)	(-3.86)	(-5.29)	(-4.20)	(-0.81)	(-3.54)	(-5.25)	(-3.31)	(0.77)
5-week dummy	0.894	1.140	1.162	1.172	0.152	0.141	0.130	0.131	0.122	0.110	0.100	0.107
	(1.20)	(2.65)	(2.66)	(2.67)	(1.48)	(2.50)	(2.28)	(2.32)	(1.35)	(2.27)	(2.05)	(2.16)
S&P 500 option return		24.997	25.348	25.169		81.214	81.366	79.592		74.131	74.401	73.626
		(8.68)	(8.73)	(8.42)		(8.34)	(8.58)	(7.73)		(8.63)	(8.68)	(8.13)
Volume/open interest			-0.025	-0.016			0.000	0.005			-0.006	-0.007
			(-0.42)	(-0.26)			(-0.01)	(0.67)			(-1.55)	(-1.62)
Option bid-ask spread			0.498	1.005			-0.132	0.001			-0.218	-0.133
			(0.54)	(1.04)			(-2.69)	(0.01)			(-4.28)	(-2.40)
IV-HV			-0.395	-0.227			-0.666	-0.622			-0.494	-0.444
			(-0.41)	(-0.26)			(-3.85)	(-3.95)			(-3.81)	(-3.54)
Log(size)				0.037				0.008				-0.003
				(0.48)				(0.98)				(-0.45)
Log(market-to-book)				-0.209				-0.033				-0.039
				(-1.55)				(-1.81)				(-2.01)
Past stock return				0.346				0.063				0.019
				(1.10)				(1.33)				(0.41)
Stock illiquidity				-51.798				-8.701				-7.605
				(-3.22)				(-5.55)				(-4.76)
Skewness				-0.093				0.002				0.000
				(-1.34)				(0.21)				(0.04)
Kurtosis				-0.068				-0.007				-0.003
				(-2.07)				(-1.19)				(-0.60)
Idiosyncratic volatility				-1.245				-5.935				-5.394
				(-0.13)				(-2.91)				(-3.33)

Table 4. Robustness checks to the regressions in Table 3

We replicate the second- and fourth-column regression models of Table 3 (referred to as "Base results") for different subsamples and estimation procedures. The first subsample excludes all months with large changes in implied volatilities, defined by differences in VIX of more than 5% in absolute value between expiration days (about 20% of the sample). The second subsample excludes months during recessions, which according to NBER definition are March 2001 to November 2001 and December 2007 to June 2009. The third subsample includes only options with moneyness between 0.95 and 1.05. The fourth subsample excludes all stocks on which options have started to trade during the past year. We also run the regressions while including fixed effects for calendar months. And finally we replicate the results for dynamically hedged options, rebalancing the number of stocks held in the portfolios according to the updated delta. We consider both weekly and daily rebalancing. This procedure applies only to the delta-hedged call and put option positions. The table reports only the coefficients (multiplied by 100) and *t*-statistics of the 5-week dummy variable, where standard errors are clustered by date. The entire sample period is 1996 to 2014.

	Straddles		Delta-hedged calls		Delta-hedged puts	
	Model 2	Model 4	Model 2	Model 4	Model 2	Model 4
Base results	1.140	1.172	0.141	0.131	0.110	0.107
	(2.65)	(2.67)	(2.50)	(2.32)	(2.27)	(2.16)
Excluding large changes in IV	1.377	1.348	0.167	0.159	0.156	0.148
	(3.70)	(3.63)	(3.27)	(3.22)	(3.57)	(3.33)
Excluding recessions	1.391	1.427	0.155	0.148	0.133	0.131
	(3.12)	(3.14)	(2.99)	(2.91)	(2.93)	(2.79)
5% moneyness	1.215	1.200	0.109	0.109	0.100	0.102
	(2.66)	(2.61)	(2.15)	(2.08)	(2.18)	(2.15)
Excluding new optionality stocks	1.156	1.166	0.138	0.140	0.102	0.105
	(2.49)	(2.51)	(2.43)	(2.42)	(2.06)	(2.05)
Calendar month effects	1.094	1.070	0.116	0.117	0.101	0.103
	(2.46)	(2.37)	(2.36)	(2.32)	(2.26)	(2.23)
Weekly rebalancing	--	--	0.085	0.065	0.278	0.304
			(2.07)	(1.62)	(2.25)	(2.44)
Daily rebalancing	--	--	0.095	0.078	0.201	0.229
			(2.84)	(2.29)	(1.82)	(2.09)

Table 5. Comparison between returns on options with 4 and 5 weeks to maturity for the same maturity day

For each calendar option expiration day (third Friday of the month), we compare the average weekly returns on option positions that are purchased four weeks and five weeks before that day and mature that day. The table reports this comparison separately for expiration days that are four and five weeks after the expiration day in the prior month. All options are subject to the same restrictions on open interest, trading volume, and moneyness as described in Table 1. The sample period is 1996 to 2014.

	Straddles		Delta-hedged calls		Delta-hedged puts	
	4 weeks between expiration days	5 weeks between expiration days	4 weeks between expiration days	5 weeks between expiration days	4 weeks between expiration days	5 weeks between expiration days
Option purchase at:						
4 weeks to expiration	-1.90%	-0.28%	-0.27%	-0.08%	-0.22%	0.00%
5 weeks to expiration	-3.86%	-1.00%	-0.36%	-0.12%	-0.32%	-0.10%

Table 6. Regression of option returns on interaction between 4-5 week maturity and institutional ownership and earnings and merger announcements

We add to the pooled regression in Table 3 interaction terms between the 5-week maturity dummy variable and three variables: Institutional Own is the sum of all shares held by institutions divided by total shares outstanding. Earnings Ann is a dummy variable that indicates if the company has reported its financial statements during the window of three, five, and seven days around the option position formation day (earnings announcements are obtained from IBES). Merger Ann is a dummy variables that indicates a merger announcement around the formation day (merger announcements are obtained from SDC). The control variables include the equivalent option-position return on the S&P 500 index (SPX), and both option characteristics (volume/open interest, bid-ask spread, and IV-HV) and stock characteristics (log(size), log(market-to-book), past stock return, stock illiquidity, return skewness, return kurtosis, and idiosyncratic volatility) as described in Table 1. All coefficients are multiplied by 100, and *t*-statistics are in parentheses, where standard errors are clustered by date. The sample period is 1996 to 2014.

	Straddles			Delta-hedged calls			Delta-hedged puts		
	3-day	5-day	7-day	3-day	5-day	7-day	3-day	5-day	7-day
Intercept	-1.966	-1.941	-1.926	-0.087	-0.081	-0.083	0.102	0.106	0.104
	(-1.46)	(-1.45)	(-1.44)	(-0.57)	(-0.53)	(-0.54)	(0.68)	(0.71)	(0.70)
5-week dummy	1.262	1.218	1.188	0.136	0.130	0.128	0.106	0.098	0.097
	(2.85)	(2.71)	(2.60)	(2.33)	(2.20)	(2.15)	(2.17)	(1.98)	(1.94)
Institutional Own	0.219	0.223	0.223	0.008	0.009	0.009	0.028	0.029	0.029
	(1.33)	(1.35)	(1.35)	(0.41)	(0.45)	(0.45)	(1.45)	(1.48)	(1.49)
5-week*Institutional Own	-0.383	-0.389	-0.386	-0.045	-0.046	-0.046	-0.025	-0.026	-0.026
	(-1.48)	(-1.51)	(-1.50)	(-1.47)	(-1.49)	(-1.49)	(-0.89)	(-0.90)	(-0.91)
Earnings Ann	-1.825	-1.427	-1.145	-0.293	-0.219	-0.171	-0.241	-0.202	-0.160
	(-4.96)	(-4.32)	(-3.46)	(-6.83)	(-5.42)	(-4.44)	(-6.98)	(-5.95)	(-4.98)
5-week*Earnings Ann	1.793	1.277	1.003	0.321	0.224	0.152	0.225	0.187	0.138
	(2.99)	(2.55)	(2.13)	(4.77)	(3.68)	(2.71)	(3.57)	(3.43)	(2.77)
Merger Ann	-0.170	-0.384	-0.161	0.016	0.025	0.039	0.031	-0.001	0.028
	(-0.27)	(-0.79)	(-0.35)	(0.28)	(0.53)	(0.90)	(0.53)	(-0.02)	(0.67)
5-week*Merger Ann	0.535	0.293	0.522	0.071	0.079	0.084	0.041	0.036	0.006
	(0.57)	(0.43)	(0.85)	(0.73)	(0.94)	(1.17)	(0.44)	(0.46)	(0.09)
S&P 500 option return	25.098	25.115	25.127	78.864	78.874	78.906	72.954	72.963	72.974
	(8.67)	(8.69)	(8.70)	(8.19)	(8.22)	(8.23)	(8.71)	(8.74)	(8.75)
Volume/open interest	-0.003	-0.004	-0.007	0.002	0.002	0.001	-0.006	-0.005	-0.006
	(-0.05)	(-0.07)	(-0.12)	(0.28)	(0.25)	(0.18)	(-1.23)	(-1.19)	(-1.26)
Option bid-ask spread	0.984	0.922	0.886	-0.016	-0.019	-0.021	-0.128	-0.131	-0.133
	(0.95)	(0.90)	(0.87)	(-0.25)	(-0.30)	(-0.33)	(-2.14)	(-2.19)	(-2.23)
IV-HV	-0.227	-0.219	-0.184	-0.623	-0.622	-0.618	-0.445	-0.445	-0.441
	(-0.26)	(-0.25)	(-0.21)	(-4.05)	(-4.05)	(-4.02)	(-3.64)	(-3.63)	(-3.60)
Log(size)	0.030	0.032	0.033	0.007	0.007	0.007	-0.003	-0.003	-0.003
	(0.38)	(0.42)	(0.43)	(0.79)	(0.80)	(0.83)	(-0.43)	(-0.39)	(-0.35)
Log(market-to-book)	-0.191	-0.189	-0.186	-0.031	-0.031	-0.031	-0.036	-0.036	-0.035
	(-1.43)	(-1.42)	(-1.40)	(-1.76)	(-1.75)	(-1.73)	(-1.94)	(-1.91)	(-1.89)
Past stock return	0.337	0.328	0.326	0.066	0.065	0.065	0.017	0.016	0.015
	(1.07)	(1.03)	(1.03)	(1.41)	(1.39)	(1.39)	(0.37)	(0.34)	(0.34)
Stock illiquidity	-50.918	-50.966	-50.951	-9.380	-9.394	-9.374	-7.731	-7.728	-7.724
	(-3.15)	(-3.16)	(-3.15)	(-5.86)	(-5.88)	(-5.86)	(-4.79)	(-4.80)	(-4.79)
Skewness	-0.048	-0.046	-0.046	0.006	0.006	0.006	0.004	0.004	0.004
	(-0.69)	(-0.67)	(-0.67)	(0.73)	(0.76)	(0.76)	(0.53)	(0.56)	(0.57)
Kurtosis	-0.062	-0.064	-0.064	-0.006	-0.007	-0.007	-0.003	-0.003	-0.003
	(-1.91)	(-1.95)	(-1.95)	(-1.12)	(-1.15)	(-1.17)	(-0.55)	(-0.60)	(-0.62)
Idiosyncratic volatility	-2.286	-2.160	-2.102	-6.238	-6.216	-6.202	-5.611	-5.603	-5.594
	(-0.24)	(-0.22)	(-0.22)	(-3.11)	(-3.10)	(-3.10)	(-3.54)	(-3.54)	(-3.53)

Table 7. Regression of option returns on interaction between 4-5 week maturity and short interest and put-call parity deviation

We add to the pooled regression in Table 3 interaction terms between the 5-week maturity dummy variable and two variables: Short interest (in log terms) is calculated by the short interest on the underlying stock divided by common shares outstanding as of the 15th of the formation month. Put-call parity deviation is measured by the average of the absolute difference between the implied volatilities of at-the-money call and put options across the different maturities. The control variables include the equivalent option-position return on the S&P 500 index (SPX), and both option characteristics (volume/open interest, bid-ask spread, and IV-HV) and stock characteristics (log(size), log(market-to-book), past stock return, stock illiquidity, return skewness, return kurtosis, and idiosyncratic volatility) as described in Table 1. All coefficients are multiplied by 100, and *t*-statistics are in parentheses, where standard errors are clustered by date. The sample period is 1996 to 2014.

	Straddles			Delta-hedged calls			Delta-hedged puts		
Intercept	-3.452	-1.318	-2.630	-0.269	-0.171	-0.296	0.090	0.179	0.147
	(-2.05)	(-1.04)	(-1.63)	(-1.49)	(-1.18)	(-1.66)	(0.56)	(1.33)	(0.92)
5-week dummy	2.217	1.169	2.311	0.236	0.126	0.234	0.196	0.100	0.199
	(3.03)	(2.57)	(3.15)	(2.71)	(2.54)	(3.39)	(2.69)	(2.12)	(3.15)
Log(short interest)	0.078		0.079	0.014		0.013	0.009		0.011
	(1.05)		(1.05)	(1.58)		(1.50)	(1.25)		(1.43)
5-week*Log(short interest)	-0.315		-0.340	-0.040		-0.046	-0.035		-0.041
	(-2.49)		(-2.59)	(-2.27)		(-2.20)	(-2.69)		(-2.63)
Put-call parity deviation		-5.078	-3.729		1.423	1.696		-3.089	-3.154
		(-1.57)	(-0.91)		(1.95)	(1.83)		(-5.14)	(-4.15)
5-week* Put-call parity deviation		10.686	15.416		1.782	4.164		2.228	3.779
		(1.57)	(1.54)		(1.04)	(1.27)		(1.73)	(1.66)
S&P 500 option return	28.803	25.330	29.255	87.923	80.365	88.926	81.154	74.260	82.171
	(8.91)	(7.81)	(8.21)	(8.25)	(7.80)	(8.37)	(8.66)	(7.93)	(8.47)
Volume/open interest	0.000	-0.009	0.009	0.012	0.004	0.011	-0.006	-0.008	-0.006
	(0.00)	(-0.15)	(0.13)	(1.61)	(0.54)	(1.57)	(-0.98)	(-1.72)	(-1.04)
Option bid-ask spread	0.292	1.021	0.214	-0.026	0.028	-0.001	-0.161	-0.097	-0.135
	(0.25)	(1.10)	(0.21)	(-0.45)	(0.48)	(-0.01)	(-2.85)	(-1.60)	(-2.22)
IV-HV	0.056	0.079	0.415	-0.547	-0.555	-0.457	-0.444	-0.350	-0.357
	(0.04)	(0.09)	(0.33)	(-2.34)	(-3.55)	(-1.99)	(-2.41)	(-2.68)	(-1.85)
Log(size)	0.135	-0.017	0.072	0.014	0.010	0.015	-0.004	-0.009	-0.008
	(1.38)	(-0.23)	(0.79)	(1.44)	(1.25)	(1.53)	(-0.43)	(-1.20)	(-0.97)
Log(market-to-book)	-0.407	-0.146	-0.345	-0.050	-0.030	-0.046	-0.049	-0.033	-0.043
	(-2.36)	(-1.14)	(-2.08)	(-2.57)	(-1.65)	(-2.34)	(-2.17)	(-1.73)	(-1.94)
Past stock return	-0.051	0.331	-0.072	-0.065	0.065	-0.062	-0.068	0.016	-0.077
	(-0.11)	(1.07)	(-0.16)	(-0.98)	(1.38)	(-0.96)	(-1.12)	(0.35)	(-1.28)
Stock illiquidity	-44.455	-58.864	-55.012	-9.773	-10.072	-11.549	-8.176	-6.743	-7.805
	(-1.85)	(-3.65)	(-2.22)	(-4.53)	(-5.68)	(-4.42)	(-3.59)	(-4.02)	(-3.17)
Skewness	-0.073	-0.081	-0.043	0.004	0.002	0.005	0.003	0.001	0.004
	(-0.81)	(-1.16)	(-0.48)	(0.45)	(0.29)	(0.57)	(0.38)	(0.13)	(0.50)
Kurtosis	-0.082	-0.065	-0.071	-0.016	-0.006	-0.013	-0.009	-0.004	-0.010
	(-1.74)	(-2.01)	(-1.54)	(-1.67)	(-1.03)	(-1.42)	(-1.19)	(-0.80)	(-1.32)
Idiosyncratic volatility	6.321	-0.458	4.871	-0.698	-6.398	-2.320	-2.895	-4.331	-1.834
	(0.35)	(-0.05)	(0.27)	(-0.17)	(-3.21)	(-0.64)	(-0.94)	(-2.68)	(-0.63)

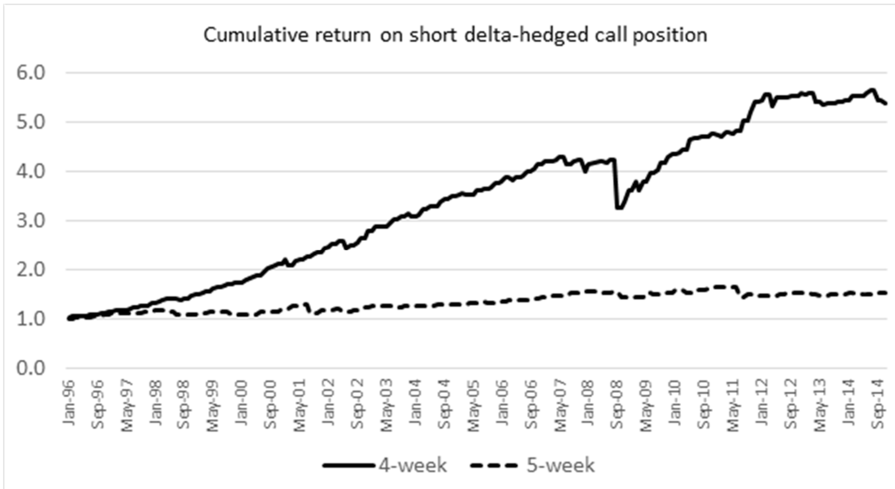
Table 8. Regression of option returns during the expiration month on the number of days until expiration and option/stock characteristics

For the three option positions described in Table 2, we run a pooled regression of the average weekly returns from the end of the month until the expiration day in the next month on the number of days until expiration. The control variables include the equivalent option-position return on the S&P 500 index (SPX), and both option characteristics (volume/open interest, bid-ask spread, and IV-HV) and stock characteristics (log(size), log(market-to-book), past stock return, stock illiquidity, return skewness, return kurtosis, and idiosyncratic volatility) as described in Table 1. All coefficients are multiplied by 100, and *t*-statistics are in parentheses, where standard errors are clustered by date. The sample period is 1996 to 2014.

	Straddles				Delta-hedged calls				Delta-hedged puts			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept	-6.848	-7.761	-7.573	-7.539	-1.316	-1.193	-1.055	-0.926	-1.018	-0.861	-0.717	-0.495
	(-1.65)	(-3.05)	(-2.94)	(-2.50)	(-2.21)	(-3.40)	(-2.99)	(-2.39)	(-1.95)	(-3.00)	(-2.47)	(-1.54)
# days to expiration	0.327	0.369	0.371	0.386	0.063	0.058	0.056	0.058	0.050	0.042	0.040	0.044
	(1.51)	(2.74)	(2.72)	(2.80)	(2.02)	(3.12)	(3.04)	(3.18)	(1.81)	(2.79)	(2.66)	(2.90)
S&P 500 option return		24.924	25.294	25.037		80.341	80.597	80.058		73.231	73.406	72.937
		(9.04)	(9.05)	(8.61)		(10.02)	(10.01)	(9.38)		(9.80)	(9.71)	(9.31)
Volume/open interest			-0.092	-0.094			-0.010	-0.004			-0.015	-0.018
			(-1.37)	(-1.23)			(-1.40)	(-0.48)			(-2.71)	(-2.79)
Option bid-ask spread			-1.173	-1.204			-0.489	-0.374			-0.546	-0.448
			(-0.90)	(-0.84)			(-7.31)	(-4.63)			(-6.99)	(-5.17)
IV-HV			-0.115	0.152			-0.393	-0.244			-0.329	-0.247
			(-0.09)	(0.13)			(-1.83)	(-1.27)			(-2.09)	(-1.62)
Log(size)				0.000				-0.007				-0.013
				(0.00)				(-0.56)				(-1.29)
Log(market-to-book)				-0.261				-0.034				-0.035
				(-1.33)				(-1.30)				(-1.33)
Past stock return				0.560				0.045				0.005
				(1.22)				(0.70)				(0.08)
Stock illiquidity				-70.273				-11.748				-12.176
				(-3.26)				(-6.05)				(-5.65)
Skewness				-0.211				-0.009				0.000
				(-2.05)				(-0.80)				(-0.04)
Kurtosis				-0.044				-0.007				-0.002
				(-0.93)				(-0.99)				(-0.32)
Idiosyncratic volatility				4.619				-1.391				-2.367
				(0.31)				(-0.45)				(-0.93)

Figure 1. Cumulative returns for 4- and 5-week maturities

The solid lines show the cumulative returns between January 1996 and December 2014 of shorting delta-hedged call and put positions during months with four weeks to next expiration day. The dashed lines show the cumulative returns of shorting delta-hedged call and put positions during months with five weeks to next expiration day. Returns on the short positions are based on the returns outlined in Table 2.



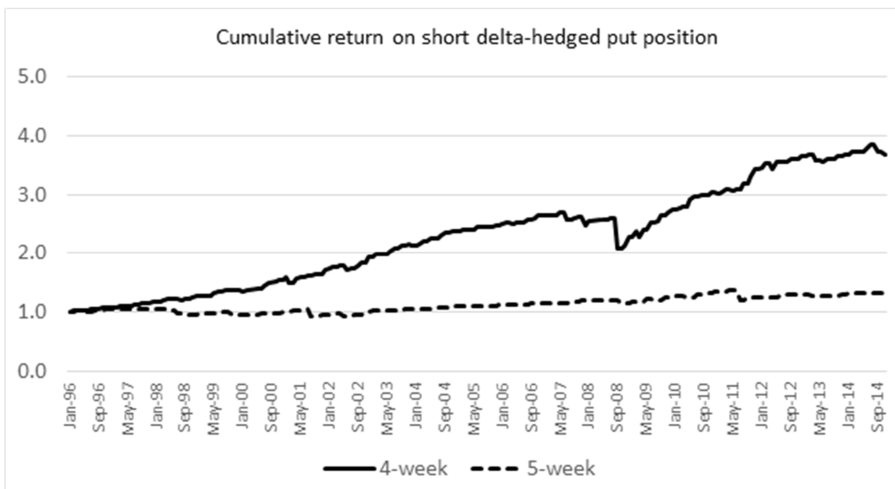


Figure 2. Option return during the formation month and expiration month

We divide the total return of each of the three option positions into two periods: the return from the option formation day until the end of the month, and the return from the end of the month until the expiration day in the next month. We regress each return (in weekly terms) on the 5-week dummy variable and the equivalent option-position return on the S&P 500 index (as in the second-column regression model of Table 3), and on both option and stock characteristics (as in the fourth-column regression model of Table 3). The figure shows only the coefficients of the 5-week dummy variable (multiplied by 100), where standard errors are clustered by date. The sample period is 1996 to 2014.