A Strange Disposition?
Option Trading, Reference Prices, and Volatility

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Abstract

Using individual stock option data, we document a classic disposition effect in addition to an effect whereby highly unfavorable positions are more likely to be liquidated. Both behaviors are more prevalent for less sophisticated investors. However, we find that for a given gain or loss, option traders are less likely to sell winners and extreme losers as volatility increases. This evidence is consistent with the notion that if traders anticipate large price movements in a given day, they are less apt to trade based on reference prices. The disposition effect also induces return predictability. When underlying stock prices increase relative to reference prices, next day option delta hedged call returns are significantly higher and put returns are significantly lower.

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1. Introduction

In a recent resurgence of interest in the classic disposition effect (Shefrin and Statman 1985; Odean 1998), several studies have questioned whether investors actually hold losers too long. For instance, Henderson (2012) and Ingersoll and Jin (2013) derive models in which traders voluntarily sell extreme losing positions. Ben-David and Hirshleifer (2012) and An (2016) find a V-shaped disposition effect whereby investors sell stocks with large gains and large losses. Moreover, Chang, Solomon, and Westerfield (2016) document that investors at a large discount broker tend to exhibit a classic disposition effect for non-delegated assets, but a reverse disposition effect for delegated assets. Moving across the spectrum from a large loss to a large gain, it is presently unclear whether the propensity to sell decreases or increases and in a linear or non-linear fashion.

The role of volatility in the disposition effect also remains an open research question. Calvet, Campbell, and Sodini (2009) find an inverse relationship between household portfolio standard deviation and households' tendency to exhibit the disposition effect. Henderson (2012) confirms this negative relation between volatility and the disposition effect in her model. Chiyachantana and Yang (2013) report that speculative investments, including high idiosyncratic volatility stocks, are associated with a weaker disposition effect. Yet, Ben-David and Hirshleifer (2012) assert that the V-shaped disposition effect is driven by a speculative motive. Building on this notion, An (2016) documents that stocks with high idiosyncratic volatility are more likely to be sold given large gains or large losses, suggesting volatility strengthens the V-shaped disposition effect.

While the disposition effect's true shape and relationship to volatility is not yet firmly established, prior studies agree that reference prices play an important role in the trading and pricing of financial securities through the disposition effect (Grinblatt and Han 2005; Birru 2015). In this paper, we examine whether the magnitude of gain or loss relative to a reference price influences option trading and returns. Our comprehensive study of U.S. option markets from 2005 to 2014 represents a new setting for testing of the well-known disposition effect. A few studies document a traditional disposition effect in derivatives, including executive stock option grants, futures, and bank-issued warrants (Heath, Huddart, and Lang 1999; Coval and Shumway 2005; Choe and Eom 2009; Schmitz and Weber 2012). Poteshman and Serbin (2003) find a disposition effect in the early exercise of exchange-traded options; however, they do not consider option trading or pricing. Our study also represents the first to our knowledge to explore whether underlying stock volatility weakens or strengthens the disposition effect among options.

We find that as an underlying stock price increases relative to an option trader's reference price, the propensity to close long call positions rises and the propensity to close long put positions falls. Yet, long call positions on stocks with extreme losses are also more likely to be closed (i.e. sold). Put trading behavior is the opposite of call trading behavior: As the underlying stock price increases relative to the reference price, puts lose value and are *less* likely to be sold. However, puts on stocks with recent extreme gains exhibit increased selling pressure. Overall, our results support the original disposition effect described by Statman and Shefrin (1985), with the important modification of increased selling pressure relative to buying pressure for highly unfavorable positions (Henderson 2012; Ingersoll and Jin 2013).

Moreover, we expect if traders anticipate large price movements in a given day, they may be less apt to trade based on their original reference prices. Thus, we predict a weaker disposition effect for higher volatility firms, similar to the predictions of Henderson's (2012) model. Our evidence strongly supports this hypothesis: For a given level of gain/loss, as idiosyncratic volatility increases, option traders are less likely to sell winners and extreme losers. Therefore, the evidence demonstrates that higher volatility significantly weakens investors' disposition to trade based on reference prices.

We calculate reference prices and capital gains overhang using a methodology similar to Grinblatt and Han (2005). Reference price is the weighted average stock price over the past 20 trading days, where option turnover is used for weighting to be more reflective of option trader framing. In the spirit of Barber and Odean (2008), we use International Securities Exchange (ISE) data to calculate the sell-buy imbalance as close sell volume-open buy volume and de-trend the series by subtracting the moving average over the past 20 trading days. Thus, we adapt methods used in prior studies on equity trading to conduct new tests of the disposition effect in options markets.

Our results are not driven by tax loss selling effects and are robust to alternative specifications of capital gains overhang. Specifically, when we re-estimate capital gains overhang using option prices rather than stock prices, we find similar results. In addition, our empirical framework of a classic disposition effect combined with an extreme loss effect – a "check mark shape" disposition effect – appears to fit the data better than a U- or V-shaped model (Choi, Hoyem, and Kim 2010; Ben-David and Hirshleifer 2012; An 2016).

Furthermore, our study documents that less sophisticated option traders exhibit a stronger disposition effect and are more prone to "give up" on extremely unfavorable positions. We find a robust disposition effect among less sophisticated customer traders and a weak disposition effect among firm traders, consistent with Feng and Seasholes (2005), Dhar and Zhu (2006), and Calvet, Campbell, and Sodini (2009). Our evidence shows that customer traders are significantly more likely to liquidate their positions if the underlying stock moves dramatically against them, while there is little evidence that firm traders do so. Volatility attenuates the strong disposition effect among customer traders, but plays a minor role in firm traders' weak disposition effect.

Option trading based on reference prices has clear return implications: Increased selling of winners should induce undervaluation and higher future returns, whereas decreased selling of losers should generate overvaluation and lower subsequent returns. We find that as capital gains overhang rises, next day delta hedged call returns are significantly higher and next day delta hedged put returns are significantly lower. Interestingly, among option positions with the poorest performance, increased selling pressure does not overwhelm the classic disposition effect as average next day option delta hedged returns remain negative. In addition, for a given level of capital gains overhang, as underlying stock volatility rises, calls become less undervalued and puts become less overvalued.

Last, our findings of the disposition effect in options trading has wider implications for the stock market. We find that the difference between call and put capital gains overhang generates stock return predictability. Consistent with Ge, Lin, and Pearson (2016), call volume has a greater impact on future stock returns relative to put volume, and the difference between call and put capital gains overhang predicts negative future stock returns, after controlling for volatility.

The rest of the paper is organized as follows. Section 2 describes the motivation and hypotheses. Section 3 outlines our data and methodology. Section 4 discusses our empirical results on options trading based on reference prices. Section 5 provides evidence on the disposition effect's implications for option and stock returns. Section 6 concludes.

2. Motivation and Hypotheses

U.S. option markets represent a new setting to examine the well-known disposition effect and to offer fresh insights as options are securities with finite lives which derive value from underlying stocks. The disposition effect refers to the phenomenon whereby investors sell winners too soon and hold losers too long (Shefrin and Statman 1985; Odean 1998). Prior literature explains the disposition effect as arising from prospect theory and realization utility: Investors show diminishing sensitivity in that they are risk-averse in the gain domain and risk-seeking in the loss domain (Kahneman and Tversky 1979; Li and Yang 2013) and view investing as a series of good or bad "episodes" depending on whether they sell at a gain or a loss (Barberis and Xiong 2009, 2012). Our study contributes to the literature on the disposition effect in non-equity securities. Heath, Huddart, and Lang (1999) document that executives exercise stock options in response to a stock reaching its 52-week high.

Poteshman and Serbin (2003) show that option traders irrationally exercise call options early after the stock reaches its yearly high or has exhibited high returns over the past few weeks or months. Coval and Shumway (2005) find that Treasury bond futures day traders take on more afternoon risk after morning losses, consistent with risk-seeking behavior in the loss domain. Choe and Eom (2009) uncover a disposition effect among traders in the Korean stock index futures market and Schmitz and Weber (2012) report a strong disposition effect for call and put bank-issued warrants among investors at a large German discount broker.

Given prior literature documenting the classic disposition effect in derivatives, one would expect greater selling pressure for winning positions and reduced selling pressure for losing positions in trading of individual options. Relative to underlying stock price changes, winning and losing positions are opposite for calls and puts: Call option prices are positively related to underlying stock prices, whereas this relationship is negative for put options. We quantify the magnitude of winning and losing positions using capital gains overhang (Grinblatt and Han 2005). This notion is formalized in our first hypothesis below.

> **Hypothesis 1:** Option traders will have a greater propensity to close versus open long call positions as capital gains overhang increases. Option traders will have a reduced propensity to close versus open long put positions as capital gains overhang increases.

However, recent research has cast doubt on the generalization that investors always hold losers too long. In the model of Henderson (2012), investors "give up" on a losing position if the asset has a low Sharpe ratio. Similarly, Ingersoll and Jin (2013) derive a model of realization utility in a dynamic setting with reinvestment that generates voluntarily realized losses.[1] In empirical studies, Calvet, Campbell, and Sodini (2009) document that Swedish households are more likely to sell extreme winners and extreme losers. Ben-David and Hirshleifer (2012) and An (2016) find a V-shaped

[1] In Ingersoll and Jin's (2013) model, investors optimize their utility by realizing losses because subsequent reinvestment resets reference prices, making realizing a future gain more likely.

disposition effect in which propensity to sell increases with the absolute magnitude of gains and losses. Chang, Solomon, and Westerfield (2016) find a reverse disposition effect in individual options trading through a large U.S. discount broker. These investors exhibit a classic disposition effect for non-delegated assets, but a reverse disposition effect for delegated assets, with the exceptions of preferred stock and options.[2] Furthermore, Henderson's (2012) model indicates investors will only liquidate large losses (far below breakeven) while they are more likely to sell when gains are closer to the breakeven.

Although the traditional disposition effect predicts investors will be least likely to sell securities with large losses, this propensity may be weaker for options than equities for two reasons. First, equity investors will not lose the entire value of their investment unless the firm becomes solvent, whereas option traders face the real possibility of options expiring worthless. Second, stocks have a theoretically infinite life, while options have finite lives. Due to options' finite lives, traders are forced to realize gains or losses at expiration if positions are not closed prior, i.e. an option expiring worthless is equivalent to a sale at a price of zero. For instance, an investor may decide to sell her OTM option prior to expiration to recover remaining time value if she does not believe the underlying price will move in her favor before expiration. An extreme underlying stock price decline reduces the probability a call will be in the money at expiration, and a dramatic stock price increase reduces the probability a put will be in the money at expiration. With a high likelihood that an option will expire OTM, she could consider it less painful to sell early, rather than being forced to face a complete loss. Thus, extreme losses could induce voluntary sales (Henderson 2012; Ingersoll and Jin 2013). On these grounds, we form a second hypothesis which predicts investors will close option positions when stock price changes have been highly unfavorable.

> **Hypothesis 2:** Option traders will have a greater propensity to close – rather than open – long call positions when the underlying stock price is very low relative to the reference price.

[2] The discount broker dataset does not distinguish between call and put options.

Furthermore, prior literature has not yet definitively established the role of volatility in the disposition effect. Calvet, Campbell, and Sodini (2009) show that households with portfolios having higher standard deviations are less likely to sell winners and more likely to sell losers. Henderson's (2012) model generates a lower probability of selling winners when volatility increases. Chiyachantana and Yang (2013) find high idiosyncratic volatility stocks are associated with a weaker disposition effect. In contrast, An (2016) reports that given large gains or large losses, stocks with higher idiosyncratic volatility are *more* likely to be sold.[3]

The relative importance of past information, i.e. unrealized gains or losses, for trading behavior may vary based upon expectations for asset price changes. Specifically, if traders anticipate high price volatility for specific options, they expect dramatic moves away from their original reference prices and may be less firmly tied to their original reference prices as a result. Consider an example: An underlying stock experiences a large price increase in a given day. If call traders did not expect a large price move, they may be more likely to sell the winner as they are faced with an unexpected gain. However, if investors were expecting a major price change due to past volatility, they may have already mentally prepared for a price run-up, prompting increases in call option values. Faced with a gain they expected, investors may be less likely to sell. Thus, investors holding assets with greater recent volatility may have an attenuated disposition effect. The same line of reasoning can be applied for a large price decrease – investors may be less prone to sell a large loser if they expected greater volatility. Our line of reasoning is most similar to Chiyachantana and Yang (2013). Our prediction is summarized in our third hypothesis.

> **Hypothesis 3**: When expected volatility is high, option trading patterns based on reference prices, as described in Hypotheses 1 and 2, will be attenuated.

[3] On a related note, Bhootra and Hur (2015) demonstrate that the negative relationship between idiosyncratic volatility and stock returns is concentrated in stocks with unrealized capital losses.

Turning from analyzing sell-buy trading imbalances to examining future returns, Hypothesis 1 has a clear implication for future option returns. Due to the classic disposition effect, we expect as capital gains overhang increases, calls will become undervalued as traders sell winners and puts will become overvalued as traders hold onto losers. While the impact of the classic disposition effect on option returns is straightforward, the return implications of selling pressure for extremely unfavorable positions are less clear-cut. Selling pressure for positions with large losses is substantially less than for even moderate gain positions (An 2016). Securities in the loss domain are typically overvalued, yet securities in the extreme loss domain are likely less to be overvalued due to increased sales. Therefore, there is no clear prediction for the sign of future returns of positions with previous large unfavorable price movements – the sign depends on whether the classic disposition effect overwhelms the drive to liquidate extremely unfavorable positions or vice versa. Moreover, based on the implications of Hypothesis 3, we expect the relationship between capital gains overhang and option returns to diminish as volatility increases. We outline these future return implications in our fourth hypothesis.

> **Hypothesis 4**: As capital gains overhang increases and propensity to sell increases, calls will become undervalued, resulting in higher future returns. As capital gains overhang increases and propensity to sell decreases, puts will become overvalued, resulting in lower future returns. The relationship between capital gains overhang and option returns will weaken as volatility increases.

Last, we consider whether the disposition effect in option trading affects future stock returns. Ge, Lin, and Pearson (2016) find increased open buy call volume predicts positive future stock returns and increased close sell call volume predicts negative future stock returns, while increased open buy put volume predicts negative future stock returns and increased close sell put volume's impact on future stock returns is insignificant. Overall, their study concludes that call volume has stronger predictive power for future stock returns as compared with put volume. Given Ge, Lin, and Pearson's findings and our hypothesis that close sell call volume should increase relative to open buy call volume as capital gains overhang rises (Hypothesis 1), we expect negative future stock returns as calls' capital gains overhang rises. Moreover, Hypothesis 1 further predicts that close sell put volume should decrease relative to open buy put volume as capital gains overhang increases, which would prompt negative future stock returns as put capital gains overhang rises, albeit with weaker predictability. Since put volume has weaker predictability as compared with call volume, we expect that call traders' experience of gains/losses vis-à-vis reference prices will have a greater impact on future stock returns than put traders' experience. In addition, we predict that greater volatility will attenuate this relationship through a weaker disposition effect in options trading. This notion is formalized in our last hypothesis below.

> **Hypothesis 5**: As the difference between call and put capital gains overhang widens, future stock returns will become more negative. This relationship will weaken as volatility increases.

3. Data and Methodology

To test our five hypotheses, we use equity option data from OptionMetrics merged with the International Securities Exchange (ISE) Open/Close Trade profile dataset, available from May 2005 to August 2014. Observations with missing or zero trading volume or open interest are excluded. The ISE dataset provides daily open buy, close buy, open sell, and close sell volume by trader class. We solely consider open buy and close sell option volume to focus on trading in long option positions. The two main trader classes are firm and customer. We combine firm and customer volume for our tests of Hypothesis 1 and 2, while we analyze customer and firm volume separately in later tests. In order to alleviate trading pattern concerns related to time to expiration, we divide the sample into four time to expiration groups: 90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration.[4]

Our key dependent variable is sell-buy imbalance, *Sell-Buy IMB*. In the spirit of Barber and Odean (2008), we define *Sell-Buy IMB* as

[4] Options with 10 or fewer to expiration are omitted due to liquidity concerns.

$$Sell\text{–}Buy\ IMB = \frac{Close\ Sell - Open\ Buy}{Close\ Sell + Open\ Buy} \tag{1}$$

where *Close Sell* refers to close sell volume and *Open Buy* refers to open buy volume. Volume is the sum of customer and firm volume from ISE. We de-trend sell-buy imbalance by the 20 day moving average sell-buy imbalance. Sell-buy imbalance captures traders' propensity to sell.

To test Hypothesis 1, our main independent variable is *CGO*, the stock capital gains overhang from the perspective of the average option trader. *CGO* is defined as

$$CGO = \frac{P_{t-2} - R_{t-1}}{P_{t-2}} \tag{2}$$

where the reference price, R_{t-1}, is equal to the weighted average stock price over the past 20 trading days (Grinblatt and Han 2005). Specifically, R_t is calculated as

$$R_t = \sum_{n=1}^{20} \left(V_{t-n} \prod_{\tau=1}^{n-1} [1 - V_{t-n+\tau}] \right) P_{t-n} \tag{3}$$

where V is option turnover and P is stock price. Option turnover is used for weighting to better reflect average underlying asset price when long option positions were opened, where option turnover is daily volume divided by open interest. The weights multiplied by each daily stock price are scaled to sum to one. If an option has traded for less than 20 prior days, we use all available data. We winsorize *CGO* at the 1% and 99% levels in accordance with An (2016).

To test Hypothesis 2, our key independent variable for calls is *XLoss*, a dummy variable which equals one if the option is in the lowest *CGO* decile in its time to expiration group. For puts, the analogous independent variable is *XGain*, a dummy variable which equals one if the stock is in the highest decile of *CGO* in its time to expiration group.

Hypothesis 3 predicts a weaker disposition effect among options with higher underlying stock volatility. We measure volatility as rolling idiosyncratic stock volatility, *StockIvol*, defined as the standard deviation of residuals of the past 20 days' returns regressed on the Fama-French three factors (Fama and French 1993; Ang, Hodrick, Xing, and Zhang 2006). Chiyachantana and Yang (2013) and An (2016) use the prior month's idiosyncratic volatility to measure volatility, while our measure is updated daily to reflect current volatility conditions.

In our examination of option return implications as outlined by Hypothesis 4, our dependent variable is delta hedged option returns, *D-H Ret*, calculated as delta hedged dollar return on day_{t+1} scaled by option price on day_t. To minimize the influence of outliers, we set any returns less than –100% or greater than 10000% to missing. To test Hypothesis 5, we use abnormal stock returns on day_{t+1} as our dependent variable. We calculate abnormal stock returns using the market model, *MMStockRet*, or Fama-French four factor model, *FFStockRet*. We define *CGODiff* as difference between the open-interest-weighted average *CGO* of calls and of puts for each stock.

Our control variables are as follows. We control for option implied volatility, bid-ask spread, time to expiration, and moneyness as well as a dummy variable for *Expiration Friday*. Implied volatility, *ImpliedVol*, is from day_{t-1}.[5] *BidAsk* is the bid-ask spread scaled by option price from day_{t-1}. Time to expiration in days is denoted as *DTE*. *K/S* is the option strike price divided by the underlying stock price and captures option moneyness. Similar to Schmitz and Weber (2012), we control for underlying asset returns over days [-4,-1] separately, cumulative buy-and-hold underlying asset returns over days [-19,-5], and underlying asset return variance over days [-19,-5] (*Stock Ret(-1)*, *Stock Ret(-2)*, *Stock Ret(-3)*, *Stock Ret(-4)*, *Stock Ret(-19,-5)*, and *Stock RetVar(-19,-5)*, respectively). Following An (2016), we also control for firm size, stock book-to-market, momentum, turnover, and idiosyncratic volatility. Firm size, *MktCap,* is the natural logarithm of the market capitalization at the end of the prior month. Stock book-to-market (*B/M*) is defined as in Fama and French (1992). *Momentum* is the cumulative monthly stock return for months $t-12$ to $t-2$. *Turnover* is average monthly stock turnover for months $t-13$ to $t-1$. We use rolling stock idiosyncratic volatility (*Stock Ivol*) defined previously as a control variable

[5] Day_0 is the date of dependent variable observation.

as well. *Expiration Friday* is a dummy variable for the third Friday of each month (or Thursday in the case of a Friday holiday), a day before options typically expire and unusually high volume occurs (Stoll and Whaley 1986, 1987; Ge, Lin, and Pearson 2016).

Table 1 presents summary statistics for our main dependent variables as well as option and underlying asset control variables for each time to expiration subsample (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration).

4. The Role of Volatility in Option Trading Based on Reference Prices

4.1. Graphical and Decile Analysis

For a preliminary look at the data, Figure 1 displays the sell-buy imbalance (*Sell-Buy IMB*) by deciles based on capital gains overhang, *CGO*.[6] Options are divided based on negative or positive *CGO* and further into loss quintiles or gain quintiles by *CGO* magnitude. For the remainder of the paper, loss quintiles will be referred to as *CGO* deciles 1-5 and gain quintiles will be referred to as *CGO* deciles 6-10. Figure 1 plots the relationship between *CGO* decile and *Sell-Buy IMB* by time to expiration group (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration) for calls in Figure 1A and puts in Figure 1B.

In Figure 1A, as *CGO* moves from decile 1 (large underlying loss) to decile 10 (large underlying gain), the sell-buy imbalance increases for calls, consistent with Hypothesis 1. Interestingly, one can see a slight increase in *Sell-Buy IMB* from decile 2 to 1, supporting the notion that investors may in fact "give up" on extreme losses (Hypothesis 2). Figure 1B shows that as CGO moves from decile 1 (large underlying loss) to decile 10 (large underlying gain), the sell-buy imbalance decreases for puts. There is also a noticeable increase in *Sell-Buy IMB* from decile 9 to 10 for puts, indicating that traders

[6] In the Appendix, we report the average CGO values by decile for each time to expiration group for calls and puts.

close long put positions on stocks with extreme gains (which represent extreme losses from a put trader's perspective).

Next, in Table 2, we perform simple two-sample *t*-tests to determine whether differences in *Sell-Buy IMB* between *CGO* deciles are significant. Specifically, for calls, we test the differences between Decile 10 – 1, Decile 10 – 2, and Decile 1 – 2 for each time to expiration group. We find differences in *Sell-Buy IMB* between Decile 10 – 1 are positive and significant at the 1% level for all time to expiration groups, indicating strong support for Hypothesis 1. Differences in *Sell-Buy IMB* between Decile 10 – 2 are not only positive and significant at the 1% level, but are larger in magnitude than Decile 10 – 1 differences. Importantly for Hypothesis 2, differences between Decile 1 – 2 are *positive* and significant at the 1% level among calls for all time to expiration groups. This evidence indicates that when the underlying stock has experienced an extreme loss relative to the average call option trader's reference point, the disposition effect reverses so that a very large loss is associated with more selling vs. buying pressure. For puts, we test the differences between Decile 10 – 1, Decile 9 – 1, and Decile 10 – 9 for each time to expiration group. Put trading behavior is opposite of that of calls: Differences in *Sell-Buy IMB* between Decile 10 – 1 are *negative* and significant at the 1% level for all time to expiration groups, supporting Hypothesis 1. Also, consistent with Hypothesis 2, differences between Decile 10 – 9 are positive and significant at the 1% level among puts for 3 of 4 time to expiration groups. Thus, puts on stocks with recent extreme gains exhibit increased selling pressure.

4.2. Main Results

We formally test Hypotheses 1 and 2 as well as Hypothesis 3 to determine the relationship of sell-buy imbalance with capital gains overhang, extremely unfavorable positions, and volatility in Table 3.[7] We consider call option trading in Panel A. First, we examine the regressions of *Sell-Buy IMB* on

[7] In all regression analyses, continuous variables are normalized to have a mean of zero and a standard deviation of one.

CGO and *XLoss* to test Hypotheses 1 and 2. Second, we include *CGO* × *StockIvol* and *XLoss* × *StockIvol* to test Hypothesis 3. All regressions include a robust set of controls as described in Section 3.[8]

Consistent with our decile analysis, *CGO* and *XLoss* coefficients are positive and statistically significant at the 1% level for calls. Without accounting for the interaction between *CGO* and volatility, a one standard deviation increase in *CGO* results in a 0.79 to 2.07 percentage point increase in the sell-buy imbalance, demonstrating that the disposition effect among call option trading is not driven by implied volatility, bid-ask spread, moneyness, prior stock returns, or other included underlying stock features. Similarly, an option in the lowest *CGO* decile (an extreme loss) has a sell-buy imbalance that is between 2.39 to 4.01 percentage points higher than all other options after controlling for *CGO* and option and stock characteristics, but not accounting for the interaction between *CGO* and volatility. This evidence indicates that a call option in the lowest CGO decile is associated with, on average, at least 2.39% more selling versus buying pressure, strongly supporting Hypothesis 2 that investors more frequently close than open long call positions on stocks with extreme losses.

Once we account for *CGO* × *StockIvol* and *XLoss* × *StockIvol*, the relationship between *Sell-Buy IMB* and *CGO* and *XLoss* becomes even stronger for calls: A one standard deviation increase in *CGO* results in a 1.62 to 4.06 percentage point increase in sell-buy imbalance, and a call option in the lowest CGO decile is associated with, on average, at least 3.26% more selling versus buying pressure. Moreover, the *CGO* × *StockIvol* coefficients are negative and significant across all time to expiration groups, indicating when underlying stocks exhibit greater volatility, call traders are less likely to exhibit the classic disposition effect. This evidence provides strong support to Hypothesis 3 and confirms the empirical findings of Calvet, Campbell, and Sodini (2009) and Chiyachantana and Yang (2013) but not those of An (2016). The *XLoss* × *StockIvol* coefficients are negative and significant in 2 of 4 time to

[8] The univariate results for the relationship between *Sell-Buy IMB* and *CGO* are reported in the Appendix. The CGO coefficient is positive and significant for calls and is negative and significant for puts across all time to expiration groups.

expiration groups, suggesting call traders are less apt to liquidate highly unfavorable positions when volatility is high, again consistent with Hypothesis 3. In the Appendix, we replace *StockIvol* in the interaction terms with *ImpliedVol* and find the similar results. Thus, volatility significantly weakens call traders' disposition to trade based on reference prices.

In Panel B, we examine put trading and replace *XLoss* with *XGain*, as extreme gains on the underlying stock represent very unfavorable positions for put traders. Across 5 of 8 models, the *CGO* coefficient is negative and significant at the 1% level. As put prices are negatively related to stock prices, these findings represent strong evidence for the disposition effect among puts, i.e. put traders' propensity to sell increases as capital gains overhang falls. The positive and significant coefficients of *XGain* in 4 of 8 specifications are consistent with the notion that put holders are more likely to sell than buy if the underlying stock price has moved dramatically against them. This evidence empirically validates put option trading based on reference prices, supporting Hypotheses 1 and 2. Furthermore, the positive and significant *CGO* × *StockIvol* coefficients in 3 of 4 models indicates that volatility significantly weakens the disposition effect among put traders. The *XLoss* × *StockIvol* coefficient is significant in only 1 of 4 models, suggesting volatility plays less of a role in the decision to liquidate highly unfavorable positions among put traders. We acknowledge that hedging pressure plays a nontrivial role in put trading.

Earnings announcements are typically associated with higher volatilities, and as such, we consider option trading around earnings announcements in untabulated results.[9] We measure earnings news content with standardized unexpected earnings (SUE) decile, following Min and Kim (2012). Choi, Hoyem, and Kim (2010) find that conditional on a given earnings surprise, capital gains overhang influences the propensity to sell a stock. We find that large paper gains accompanied

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[9] We gather earnings announcement dates from Compustat and consider options on the reported announcement date and the next day to capture responses to after-hours earnings announcements.

by more positive earnings surprises prompt greater selling pressure relative to buying pressure in call options.[10] Furthermore, our untabulated results show that volatility mitigates the propensity to close long call positions on stocks with higher capital gains overhang and more positive earnings surprises.

Overall, these results demonstrate that option traders have a greater propensity to close vs. open long call positions and a reduced propensity to close vs. open long put positions as the underlying stock rises above the reference price (Hypothesis 1). Yet, the traditional disposition effect reverses for calls when the underlying has substantially fallen in price, whereas the effect reverses for puts when the underlying has substantially risen in price (Hypothesis 2). In addition, we provide strong evidence that volatility attenuates the classic disposition effect among both calls and puts, while there is some evidence that volatility also weakens call traders' propensity to liquidate highly unfavorable positions.

4.3. January vs. February-December

Prior work on the disposition effect acknowledges the impact of tax-loss motivated selling in December (Odean 1998; Grinblatt and Han 2005; An 2016). Following An (2016), we report our main results for January only and February-December in Table 4. Panel A demonstrates that among calls the disposition effect, captured by *CGO*, is most robust in the February-December months: Across all time to expiration groups, the *CGO* coefficient is positive and significant at the 1% level. The *CGO* coefficient is significant in 5 of 8 time to expiration groups for January only. In contrast to Grinblatt and Han's results for the stock market, we do not find a reversal of the disposition effect in option markets in January, likely because we use a much shorter window for calculating reference prices to reflect an option trader's perspective. Moreover, the sell-buy imbalance is significantly higher for extreme loss positions across all time to expiration groups for February-December. In January, *XLoss*

[10] Our results are consistent with Choi, Hoyem, and Kim's (2010) findings with one exception: Their results are strongest among stocks with capital losses and negative earnings surprises. The difference could be attributed to differences in security type (stock vs. option), sample period, or methodology.

coefficients are significant for calls in only 2 of 8 models while *XLoss* coefficients for the remaining time to expiration groups are insignificant. Also, *CGO* × *StockIvol* and *XLoss* × *StockIvol* play a much more significant role in weakening the disposition effect and decision to liquidate highly unfavorable positions in February-December as compared with January, indicating our findings for volatility's role in the disposition effect are not related to a turn-of-the-year effect.

We draw similar conclusions when we examine put trading in January and February-December separately in Panel B. The *CGO* coefficient is negative and significant in 6 of 8 specifications in February-November, but only in 1 of 8 specifications in January. The decision to liquidate put positions on underlying stocks that have experienced recent large gains as well as volatility's weakening of the disposition effect are both more pronounced in February-November as compared with January only.

Overall, option trading based on reference prices is most robust in February-November, indicating our main results are not driven by a tax loss selling effect.

4.4. Robustness

Choi, Hoyem, and Kim (2010), Ben-David and Hirshleifer (2012), and An (2016) find a "U-shaped" or "V-shaped" disposition effect. In contrast, our model thus far assumes a classic disposition effect combined with an extreme loss effect – a disposition effect that looks more like a check mark than a V. In our next test, we examine the fit of a V-shaped model for our data. Similar to Choi, Hoyem, and Kim (2010), we define *CGO Gain* as equal to *CGO* if *CGO* is greater than zero and as equal to zero otherwise. *CGO Loss* is equal to *CGO* if *CGO* is less than zero and zero otherwise.

In Table 5 Panel A.1, we regress *Sell-Buy IMB* on *CGO Gain* and *CGO Loss*. *CGO Gain* coefficients are positive and significant at the 1% level across all time to expiration groups. As compared with the *CGO* coefficients in Table 3 Panel A, *CGO Gain* is smaller in magnitude for all options with the exception of those with 30-11 days to expiration. Turning to *CGO Loss*, the coefficients are insignificant in all but one specification, in which the coefficient is negative and small in economic magnitude. In contrast to *CGO Loss*, *XLoss* coefficients in Table 3 Panel A show greater economic and statistical significance across all time to expiration groups. In addition, *CGOGain* × *StockIvol* coefficients are negative and significant across all 4 models where the term is included, supporting the results of Calvet, Campbell, and Sodini (2009) and Chiyachantana and Yang (2013). *CGOLoss* × *StockIvol* are negative and significant for the 90-71 days to expiration group, positive and significant for 50-31 days to expiration group, and insignificant for the remaining groups. Table 5 Panel B.1 draws similar inferences based on put trading. Put trading is perhaps better explained by *CGO* and *XGain* than *CGOGain* and *CGOLoss*. *CGOLoss* captures some variation in put trading, but *CGOGain* is only significant in 1 of 8 specifications. Therefore, the evidence suggests the classic disposition effect accompanied by the decision to liquidate highly unprofitable positions may better match the true model of option trading based on reference prices.

Although we incorporate option turnover in our capital gains overhang calculation, we use the underlying stock price instead of option price as investors' anchoring price. We choose not to use option prices because Bauer, Cosemans, and Eichholtz (2009) report that only a small subset of investors considers option Greeks; therefore, underlying stock prices are much more salient as compared with option prices in the mind of the average option trader (especially a retail investor). Nevertheless, for robustness, we re-calculate capital gains overhang using option prices rather than stock prices and denote this measure as *OCGO*. Since we are examining put prices rather than underlying stock prices, the interpretation of *OCGO* changes for puts: As *OCGO* increases, puts rise in value and therefore we expect increased selling vs. buying pressure. Also, *OXLoss,* rather than *OXGain,* is appropriate for puts as highly unfavorable positions occur when the put price has fallen dramatically in value.

We report the results using *OCGO* and *OXLoss* for calls and puts in Panels A.2 and B.2, respectively. For calls in Panel A.2, the results are very similar to our original specifications in Table 2 Panel A: *OCGO* coefficients are positive and significant across all time to expiration groups, *OXLoss* coefficients are positive and significant in 5 of 8 specifications, and *OCGO* × *StockIvol* coefficients are negative and significant in 3 of 4 models where the interaction term is included. The only difference, in contrast to Table 2 Panel A, is the insignificance of *OXLoss* × *StockIvol* in all 4 models. For puts in Panel B.2, *OCGO* coefficients are positive and significant across 7 of 8 time to expiration groups, indicating that as put prices rise relative to past put prices, put traders are more likely to close long positions. Also, *OCGO* × *StockIvol* coefficients are negative and significant in 2 of 4 models. This evidence is consistent with a disposition effect in put trading which is mitigated by volatility. Interestingly, put traders are less likely to close highly unprofitable positions when capital gains overhang is measured using put prices, which is in contrast to our results in Table 2 Panel B. Despite this contrast, the general message is clear: The disposition effect in option trading and the role of volatility is similar whether we measure capital gains overhang using underlying stock prices or option prices.

4.5. Customer vs. Firm Trading

Prior studies document that less sophisticated investors exhibit a strong disposition effect in equity trading (Feng and Seasholes 2005; Dhar and Zhu 2006). Given prior work, we expect to observe the same behavior for less sophisticated options traders (Hypothesis 3). In addition, prior studies have shown greater selling pressure for extreme losing positions by individual investors and among stocks preferred by retail investors (Ben-David and Hirshleifer 2012; An 2016). Thus, we predict customer traders, rather than firm traders, will be more likely to sell highly unfavorable positions. To test these notions, we calculate customer sell-buy imbalance (*Customer Sell-Buy IMB*) and firm sell-buy imbalance

(*Firm Sell-Buy IMB*) as the sell-buy imbalance for customer traders and firm traders, respectively. We also compute the difference between the two (*Customer – Firm Sell-Buy IMB*). We regress each dependent variable on *CGO*, *XLoss*, and option and stock characteristic control variables and in separate models include *CGO* × *StockIvol* and *XLoss* × *StockIvol* as well.

Table 6 Panel A reports results for calls. In Panel A.1, the dependent variable is *Customer Sell-Buy IMB*. The *CGO* coefficient is positive and significant across all time to expiration groups, indicating the classic disposition effect is robust among customer trades. The *XLoss* coefficient is also positive and significant across all specifications, demonstrating that customer traders tend to sell calls on stocks with very large losses. *CGO* × *StockIvol* and *XLoss* × *StockIvol* are negative and significant in 4 of 4 and 2 of 4 specifications, respectively. Panel A.2 repeats the analysis of Panel A.1 using *Firm Sell-Buy IMB* as the dependent variable. The *CGO* coefficients are significant in 5 of 8 specifications and *XLoss* coefficients are significant in only 1 of 8 models, and in all but one case, both coefficients are substantially smaller in magnitude as compared with the *CGO* and *XLoss* coefficients in Panel A.1. Further, *CGO* × *StockIvol* coefficients are only significant in 1 of 4 specifications, while *CGO* × *XLoss* coefficients are significant in 2 of 4 models. Notably, Panel C uses the same specifications with *Customer – Firm Sell-Buy IMB* as the dependent variable to test for significant differences between customer and firm trading. The *CGO* coefficient is positive and significant at the 1% level in 6 of 8 specifications and the *XLoss* coefficient is positive and significant in all 8 specifications. The strongly negative coefficients on *CGO* × *StockIvol* provide further evidence that customer traders in particular are less prone to liquidating winners when volatility is high. In sum, these results support the notion that less sophisticated option traders more strongly exhibit trading behavior consistent with the traditional disposition effect, but are also more likely to close long call positions on stocks with extreme losses relative to reference prices.

In addition, in Panels B, we explore whether retail investors' propensity to close long put positions is greater than that of institutional investors as capital gains overhang decreases. We omit a discussion of Panels B.1 and B.2 for brevity and focus on Panel B.3 where the dependent variable is *Customer – Firm Sell-Buy IMB*. Panel B.3 reports negative and significant *CGO* coefficients across 4 of 8 specifications, suggesting customer traders exhibit a stronger disposition effect than firm traders as they are more likely to sell puts on stocks that have experienced large recent price declines. The *XGain* coefficient is positive and significant in 2 of 8 specifications, indicating limited evidence that customer traders are more likely than firm traders to sell puts following large stock price run-ups relative to reference prices. *CGO* × *StockIvol* coefficients are significant in 2 of 4 specifications and *CGO* × *XGain* coefficients are significant in 1 of 4 specifications. As compared with calls, differences between customer trading and firm trading is less pronounced for puts, yet there remains some evidence that retail investors exhibit a greater tendency to sell vs. buy as capital gains overhang increases, while this behavior weakens as volatility rises.[11]

These findings represent the first evidence that less sophisticated option traders exhibit a highly robust classic disposition effect, while sophisticated option traders demonstrate an attenuated disposition effect. Volatility weakens the disposition effect among customer traders, but plays a minor role in firm traders' weak disposition effect. Moreover, in call option trading, a greater sell-buy imbalance for extreme loss positions is almost exclusively driven by customer traders. This evidence provides further empirical support for the notion that a tendency to liquidate highly unfavorable positions is most prevalent in retail investor trading.

5. Implications for Option and Stock Returns

[11] Lakonishok, Lee, Pearson, and Poteshman (2007) find that retail investors are four times more likely to open call positions than put positions, which could partially explain why our results for customer vs. firm traders are weaker for puts.

5.1. Option Returns

As stated in Hypothesis 4, we predict that as capital gains overhang increases and investors increasingly sell winners, calls will become undervalued and have higher future returns. Conversely, as capital gains overhang rises and put traders hold onto losing positions, puts will become overvalued and have lower future returns. Since the disposition effect is also manifest in underlying stock trading, we consider delta-hedged option returns in order to remove option price changes due to underlying stock price movements. Therefore, our dependent variable is *D-HRet*, the delta hedged dollar return on day_{t+1} scaled by option price on day_t. In Table 7 Panel A, we regress call *D-HRet* on *CGO*, *XLoss*, and option and stock characteristic control variables and in additional specifications include *CGO* × *StockIvol* and *CGO* × *XLoss*. In Table 7 Panel B, we analyze put option returns, specifically we use put *D-HRet* and substitute *XGain* for *XLoss*.

In Panel A, *CGO* coefficients are positive and significant at the 1% level across all time to expiration groups: A one standard deviation increase in *CGO* is associated with a 30 to 99 basis point higher day_{t+1} delta-hedged call return. The positive, economically significant *CGO* coefficients strongly support Hypothesis 4. In addition, the *XLoss* coefficient is negative and significant across time to expiration groups, suggesting the extreme loss effect is subsumed by the disposition effect. In other words, although there is increased selling pressure for options in the lowest *CGO* decile, this pressure does not fully offset the impact of the disposition effect. As depicted in Figure 1, the *Sell-Buy IMB* coefficient is significantly larger for *CGO* Decile 1 relative to Decile 2, but is significantly smaller relative to Decile 10. Thus, the selling pressure in Decile 1 is not strong enough to induce undervaluation among options in this category. Rather, Panel A provides evidence that these options remain overvalued. Additionally, in Panel A we explore the impact of idiosyncratic volatility and reference prices on next day delta-hedged call returns. If volatility weakens the disposition effect, then calls with higher volatility and greater capital gains overhang should be associated with less undervaluation and thus incrementally lower future returns. We test this conjecture by adding *CGO* × *StockIvol* and *XLoss* × *StockIvol* to our models. *CGO* × *StockIvol* coefficients are negative and significant in 4 of 4 specifications, consistent with the notion of less pronounced undervaluation among options on underlying stocks with greater volatility.[12]

Panel B examines the pricing implications of the disposition effect in put options. Specifically, Delta-hedged put return results show negative and significant *CGO* coefficients for 7 of 8 specifications, indicating strong support for Hypothesis 4. *XGain* coefficients are negative and significant in 5 of 8 models, demonstrating the tendency to hold losers is not fully offset by a desire to liquidate highly unprofitable positions. *CGO* × *StockIvol* is positive and significant in 2 of 4 models, showing that volatility reduces the negative put return predictability stemming from the disposition effect.

Table 7 provides convincing evidence that the disposition effect in option markets has meaningful option return implications: As capital gains overhang increases, future delta-hedged call returns increase while put returns decrease. Volatility attenuates both these effects.

5.2. Stock Returns

Last, we examine whether the disposition effect in option trading affects future stock returns. Ge, Lin, and Pearson (2016) find that call volume has stronger predictive power for future stock returns as compared with put volume. Specifically, their study documents that open buy call volume predicts positive future stock returns and close sell call volume predicts negative future stock returns, while open buy put volume predicts negative future stock returns and close sell put volume's impact on future stock returns is insignificant. Since we find call option sell-buy imbalance increases with

[12] The *XLoss* × *Implied Vol* coefficient is positive and significant in 2 of 4 specifications, which is inconsistent with an undervaluation explanation as Table 3 Panel B shows a lower *Sell-Buy IMB* for options in the *XLoss* category with higher volatility. We acknowledge that other factors may be playing a role in call returns for extreme loss positions.

capital gains overhang, negative future stock returns should be manifest as capital gains overhang increases. Moreover, our results demonstrate that put option sell-buy imbalance decreases as capital gains overhang increases, which should prompt negative future stock returns, albeit with weaker predictability. Since put volume has weaker predictability as compared with call volume, we expect call traders' capital gains overhang will have a greater impact on future stock returns than put traders' capital gains overhang (Hypothesis 5). We also predict in Hypothesis 5 that greater volatility will attenuate the relationship between negative stock return predictability and the difference between call and put capital gain overhang.

To test our predictions, we regress *StockRet* on *CGODiff* and *CGODiff* × *StockIvol* as well as stock characteristic control variables. As described in Section 3, *CGODiff* is the difference between the open-interest-weighted average *CGO* of calls and of puts on each stock. Table 8 reports the results. Contrary to the first part of Hypothesis 5, *CGODiff* is insignificant when *CGODiff* × *StockIvol* is omitted. However, once *CGODiff* × *StockIvol* is included, *CGODiff* is rendered *negative* and significant, supporting Hypothesis 5. In economic terms, a one standard deviation increase in *CGODiff* is accompanied by an average of 3 bps drop in the underlying stock abnormal return on day_{t+1}, regardless of whether the market model or Fama-French four factor model is used. Furthermore, *CGODiff* × *StockIvol* is positive and significant, demonstrating volatility weakens the negative stock return predictability of *CGODiff*.

Consistent with Ge, Lin, and Pearson (2016), call volume has a greater impact on future stock return predictability relative to put volume, and once the role of volatility is accounted for, the predictability is in the direction suggested by their study. Therefore, our findings of the disposition effect in options trading has wider implications for the stock market.

6. Conclusion

In a comprehensive study of U.S. option markets from 2005 to 2014, we find a robust disposition effect in option trading and returns. Specifically, the option close sell-open buy imbalance is significantly related to the magnitude of gains and losses relative to reference prices. We find evidence of both a classic disposition effect (Shefrin and Statman 1985) and an extreme loss effect (Henderson 2012; Ingersoll and Jin 2013). Both effects are significantly stronger among unsophisticated traders relative to sophisticated traders. Our study is the first to document that option trading based on reference prices is attenuated by volatility.

Our approach differs from prior literature in that we adapt the methodology of Grinblatt and Han (2005) to calculate reference prices and capital gains overhang from an option trader's perspective. Reference price is the weighted average stock price over the past 20 trading days, where option turnover is used for weighting to be more reflective of option trader framing. We find that as capital gains overhang rises, the sell-buy imbalance for call options increases and for put options decreases. Moreover, as capital gains overhang rises and selling pressure for winners increases, next day delta-hedged call returns are significantly higher as well, consistent with a correction to selling-induced undervaluation. In contrast, next day delta-hedged put returns decrease as capital gains overhang increases and selling pressure diminishes, consistent with correction of overvaluation. Overall, our findings offer a new perspective on the disposition effect through the lens of option trading based on reference prices.

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Figure 1: Sell-Buy Imbalance by Capital Gains Overhang Decile

This figure displays the sell-buy imbalance (*Sell-Buy IMB*) by capital gains overhang (*CGO*) decile. The sample is divided into four subsamples by time to expiration: 90-71 days, 70-51 days, 50-31 days, and 30-11 days. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). *Sell-Buy IMB* is in percent. Figure 1A presents the *Sell-Buy IMB* by *CGO* decile for calls, while Figure 1B does so for puts. The sample period is from May 2005 to August 2014.

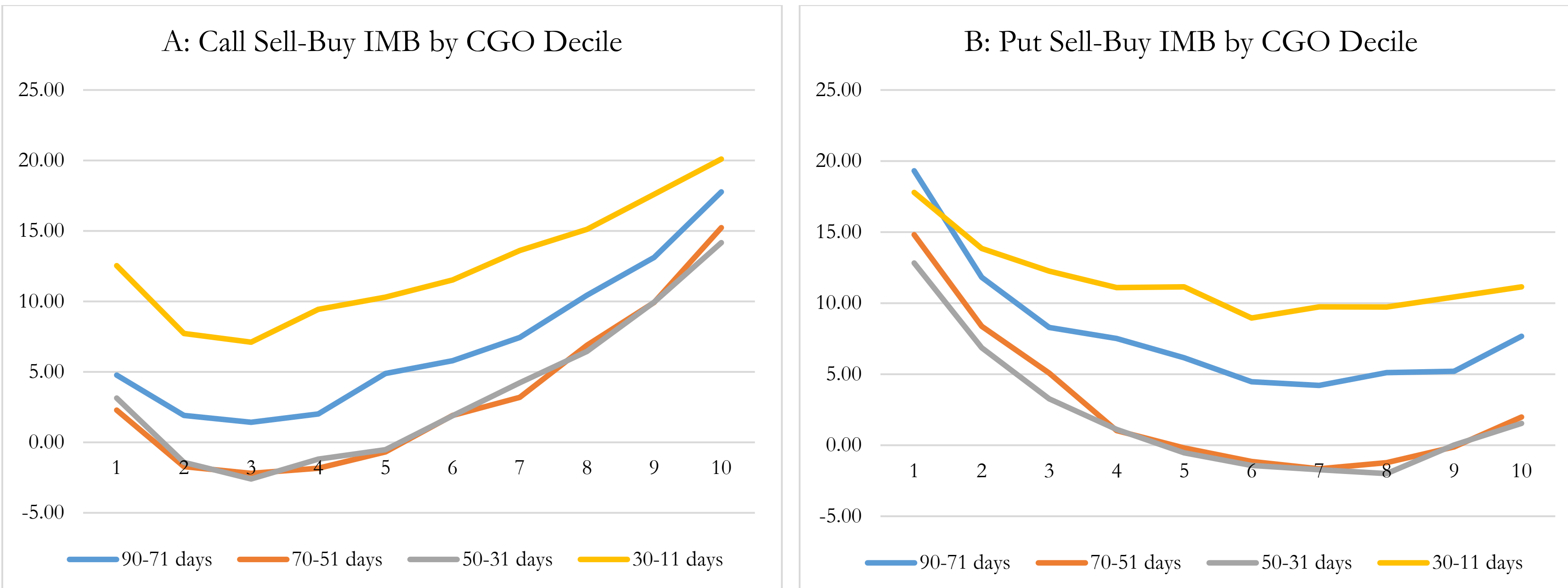

Table 1: Summary Statistics

This table reports the summary statistics by time to expiration group (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration). *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *Customer Sell-Buy IMB* is customer trader sell-buy imbalance. *Firm Sell-Buy IMB* is firm trader sell-buy imbalance. *D-HRet* is the dollar delta-hedged return on day_{t+1} scaled by option price on day_t. *ImpliedVol* is implied volatility of the day_{t-1} (annualized). *BidAsk* is the bid-ask spread scaled by option price. *K/S* is the option strike price divided by the underlying stock price. Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *Stock Ret(-1)*, *Stock Ret(-2)*, *Stock Ret(-3)*, and *Stock Ret(-4)* are the underlying stock's returns one day, two days, three days, and four days prior, respectively. *Stock Ret(-19,-5)* is the cumulative buy-and-hold return from days -19 to -5. *Stock RetVar(-19,-5)* is the squared average stock return from days -19 to -5. *Mktcap* is market capitalization in billions (in all remaining tables, *MktCap* refers to the natural logarithm of market capitalization). *B/M* (book-to-market) is defined as in Fama and French (1992). *Momentum* is the cumulative monthly stock return from month $t-12$ to $t-2$ in percent. *Turnover* is average monthly stock turnover from month $t-13$ to $t-1$. All variables are reported in percent, except for *BidAsk*, *K/S*, *MktCap*, *B/M*, and *Turnover*. The sample period is from May 2005 to August 2014.

Panel A: Calls

	90-71 days	70-51 days	50-31 days	30-11 days
Sell-Buy IMB	7.24	3.47	3.68	12.72
Customer Sell-Buy IMB	6.76	2.81	3.07	12.17
Firm Sell-Buy IMB	0.67	0.31	-0.21	0.95
D-HRet	0.59	-0.18	0.19	0.02
ImpliedVol	39.92	40.61	41.12	41.17
BidAsk	0.12	0.14	0.18	0.27
K/S	1.08	1.07	1.07	1.04
StockIvol	1.81	1.79	1.79	1.78
StockRet(-1)	0.09	0.12	0.10	0.09
StockRet(-2)	0.08	0.06	0.10	0.11
StockRet(-3)	0.12	0.03	0.13	0.09
StockRet(-4)	0.11	0.04	0.13	0.08
StockRet(-19,-5)	0.04	0.03	0.04	0.06
StockRetVar(-19,-5)	0.10	0.10	0.10	0.10
MktCap	52.70	54.14	50.83	47.41
B/M	0.42	0.42	0.43	0.43
Momentum	23.43	23.74	23.61	23.64
Turnover	384.08	390.06	397.66	397.71
N	411,656	472,642	586,698	633,891

Panel B: Puts

	90-71 days	70-51 days	50-31 days	30-11 days
Sell-Buy IMB	7.87	2.71	1.91	11.58
Customer Sell-Buy IMB	6.56	0.89	0.58	10.85
Firm Sell-Buy IMB	1.64	1.36	0.41	0.91
D-HRet	0.27	-0.49	-0.72	-1.24
ImpliedVol	44.57	45.12	45.36	45.74
BidAsk	0.09	0.10	0.14	0.24
K/S	0.95	0.96	0.97	0.97
StockIvol	1.83	1.80	1.76	1.78
StockRet(-1)	-0.04	0.01	-0.01	-0.02
StockRet(-2)	0.00	-0.03	0.01	0.02
StockRet(-3)	0.05	-0.07	0.07	0.00
StockRet(-4)	0.05	-0.06	0.08	0.01
StockRet(-19,-5)	-0.01	-0.02	-0.03	-0.01
StockRetVar(-19,-5)	0.12	0.10	0.10	0.10
MktCap	65.96	67.08	62.31	56.60
B/M	0.46	0.46	0.47	0.46
Momentum	15.92	17.81	18.68	18.76
Turnover	393.12	397.56	405.21	407.54
N	194,412	255,109	371,668	438,791

Table 2: Decile Analysis

This table reports a decile analysis of average sell-buy imbalance, *Sell-Buy IMB*, by capital gains overhang, *CGO*, decile. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). We calculate *Sell-Buy IMB* decile average differences between Decile 10 and 1, Decile 10 and 2, and Decile 1 and 2 for calls in Panel A and differences between Decile 10 and 1, Decile 9 and 1, and Decile 10 and 9 for puts in Panel B. This table report averages and differences in percent for each time to expiration group (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration). *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed two-sample *t*-test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A: Calls

CGO Decile	90-71 days	70-51 days	50-31 days	30-11 days
1	4.77	2.28	3.14	12.54
2	1.91	-1.72	-1.42	7.72
3	1.42	-2.20	-2.60	7.11
4	2.01	-1.84	-1.19	9.44
5	4.89	-0.68	-0.52	10.30
6	5.79	1.91	1.89	11.52
7	7.44	3.19	4.23	13.61
8	10.44	6.89	6.45	15.11
9	13.12	9.92	9.95	17.60
10	17.77	15.23	14.17	20.10
10-1	13.00***	12.95***	11.03***	7.56***
	(25.19)	(27.00)	(25.77)	(18.88)
10-2	15.86***	16.95***	15.59***	12.38***
	(30.47)	(34.94)	(36.09)	(30.45)
1-2	2.86***	4.00***	4.57***	4.82***
	(5.52)	(8.40)	(10.46)	(11.52)

Panel B: Puts

CGO Decile	90-71 days	70-51 days	50-31 days	30-11 days
1	19.31	14.82	12.82	17.79
2	11.82	8.37	6.86	13.85
3	8.29	5.08	3.26	12.25
4	7.51	1.03	1.11	11.09
5	6.16	-0.20	-0.53	11.15
6	4.47	-1.15	-1.42	8.95
7	4.21	-1.66	-1.72	9.74
8	5.11	-1.23	-2.00	9.72
9	5.20	-0.12	0.01	10.43
10	7.67	1.98	1.54	11.15
10-1	-11.65***	-12.83***	-11.29***	-6.64***
	(-15.42)	(-19.66)	(-21.08)	(-13.67)
9-1	-14.11***	-14.94***	-12.81***	-7.36***
	(-18.69)	(-22.80)	(-23.75)	(-15.07)
10-9	2.47***	2.11***	1.53***	0.72
	(3.40)	(3.25)	(2.87)	(1.45)

Table 3: The Disposition Effect and Role of Volatility

This table explores the disposition effect and role of volatility in option trading. The sample is divided into four subsamples by time to expiration: 90-71 days, 70-51 days, 50-31 days, and 30-11 days. The dependent variable is sell-buy imbalance, *Sell-Buy IMB*. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). *XLoss* is a dummy variable which equals one if the option is in the lowest decile of *CGO* in its time to expiration subsample. *XGain* is a dummy variable which equals one if the option is in the highest decile of *CGO* in its time to expiration group. Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *CGO* × *StockIvol*, *XLoss* × *StockIvol*, and *XGain* × *StockIvol* are interaction terms. Panel A reports the results for calls, while Panel B does so for puts. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A: Calls

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	1.41***	2.55***	2.07***	4.06***	1.75***	3.17***	0.79***	1.62***
	(4.57)	(5.72)	(7.23)	(9.40)	(7.20)	(8.71)	(3.26)	(4.37)
XLoss	2.52***	3.26**	4.01***	7.92***	3.36***	7.91***	2.39***	3.76***
	(3.35)	(2.26)	(5.68)	(5.64)	(5.25)	(6.31)	(3.62)	(2.93)
CGO × StockIvol		-2.18***		-3.47***		-2.63***		-1.72***
		(-3.47)		(-6.13)		(-5.29)		(-2.95)
XLoss × StockIvol		-0.37		-1.75***		-2.08***		-0.69
		(-0.62)		(-3.26)		(-4.24)		(-1.29)
StockIvol	1.14**	1.17**	0.25	0.51	2.48***	3.00***	1.93***	2.06***
	(2.20)	(2.18)	(0.54)	(1.06)	(5.30)	(6.21)	(3.96)	(4.13)
ImpliedVol	10.10***	9.88***	11.01***	10.78***	8.68***	8.61***	3.30***	3.28***
	(10.75)	(10.50)	(12.83)	(12.55)	(13.93)	(13.80)	(7.60)	(7.56)
BidAsk	3.43***	3.45***	3.58***	3.59***	4.44***	4.45***	7.30***	7.31***
	(9.95)	(10.01)	(10.67)	(10.70)	(15.46)	(15.50)	(27.22)	(27.26)
DTE	-0.22***	-0.22***	0.10***	0.10***	-0.12***	-0.12***	-0.96***	-0.96***
	(-9.52)	(-9.54)	(4.63)	(4.64)	(-6.33)	(-6.27)	(-47.19)	(-47.20)
K/S	-12.72***	-12.99***	-8.45***	-8.62***	-23.47***	-23.67***	-13.67***	-13.71***
	(-15.53)	(-15.81)	(-11.38)	(-11.59)	(-10.13)	(-10.21)	(-20.33)	(-20.39)

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	90-71 days		70-51 days		50-31 days		30-11 days	
StockRet(-1)	0.62***	0.58***	1.42***	1.36***	2.25***	2.22***	3.03***	2.99***
	(3.67)	(3.37)	(9.09)	(8.68)	(16.21)	(15.89)	(20.23)	(19.94)
StockRet(-2)	0.55***	0.61***	1.25***	1.34***	2.08***	2.11***	2.15***	2.18***
	(3.11)	(3.48)	(7.69)	(8.21)	(14.59)	(14.74)	(14.29)	(14.45)
StockRet(-3)	0.30*	0.35**	0.96***	0.99***	1.40***	1.42***	1.51***	1.52***
	(1.76)	(2.09)	(6.12)	(6.33)	(10.13)	(10.27)	(10.32)	(10.37)
StockRet(-4)	0.20	0.25	0.79***	0.85***	1.28***	1.30***	0.77***	0.79***
	(1.23)	(1.54)	(5.10)	(5.44)	(9.38)	(9.54)	(5.40)	(5.50)
StockRet(-19,-5)	-0.99***	-0.91***	0.59**	0.66**	1.32***	1.35***	0.98***	0.98***
	(-3.40)	(-3.13)	(2.08)	(2.30)	(5.28)	(5.41)	(3.77)	(3.78)
StockRetVar(-19,-5)	1.53***	1.43**	0.21	0.43	-0.39	-0.33	1.76***	1.78***
	(2.64)	(2.47)	(0.68)	(1.35)	(-0.63)	(-0.53)	(4.29)	(4.33)
MktCap	-27.83***	-27.84***	-19.49*	-18.57	-17.49**	-17.62**	-19.59***	-19.61***
	(-7.03)	(-7.03)	(-1.65)	(-1.58)	(-2.51)	(-2.53)	(-5.13)	(-5.14)
B/M	-4.30	-4.31	4.98	4.51	-2.42	-2.70	-10.34***	-10.34***
	(-1.44)	(-1.45)	(0.70)	(0.64)	(-0.54)	(-0.60)	(-3.39)	(-3.40)
Momentum	0.15	0.15	1.65	1.79	-0.59	-0.60	0.49	0.49
	(0.26)	(0.26)	(1.15)	(1.24)	(-0.46)	(-0.46)	(1.07)	(1.06)
Turnover	-4.68*	-4.44	19.38**	19.03**	-1.68	-2.20	-2.30	-2.24
	(-1.72)	(-1.64)	(2.31)	(2.27)	(-0.32)	(-0.41)	(-0.82)	(-0.80)
Expiration Friday	-1.79*	-1.75*	-1.57***	-1.57***	-1.48***	-1.48***	-4.20***	-4.17***
	(-1.71)	(-1.67)	(-2.95)	(-2.95)	(-3.54)	(-3.53)	(-3.92)	(-3.90)
N	382,764	382,764	434,945	434,945	528,150	528,150	525,116	525,116

Panel B: Puts

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	-0.60	-1.37**	-0.86**	-2.34***	-0.95***	-1.65***	-0.34	-0.66
	(-1.36)	(-2.28)	(-2.25)	(-4.16)	(-3.28)	(-3.93)	(-1.25)	(-1.57)
XGain	2.32**	0.71	1.27	0.67	1.12*	3.03**	1.53**	0.76
	(2.46)	(0.43)	(1.52)	(0.43)	(1.67)	(2.46)	(2.32)	(0.60)
CGO × StockIvol		1.32*		2.48***		1.29**		0.61
		(1.79)		(3.52)		(2.32)		(0.96)
XGain × StockIvol		0.76		0.28		-0.85*		0.34
		(1.18)		(0.48)		(-1.85)		(0.71)
StockIvol	0.07	-0.14	1.17*	1.35**	1.89***	2.19***	2.03***	2.01***
	(0.08)	(-0.16)	(1.88)	(2.06)	(3.02)	(3.41)	(3.31)	(3.19)
ImpliedVol	0.50	0.73	3.69***	3.85***	3.61***	3.66***	-1.48***	-1.48***
	(0.34)	(0.50)	(3.31)	(3.45)	(4.19)	(4.25)	(-2.49)	(-2.48)
BidAsk	3.50***	3.51***	4.07***	4.12***	4.84***	4.85***	7.18***	7.20***
	(7.25)	(7.27)	(9.70)	(9.81)	(14.77)	(14.79)	(25.24)	(25.28)
Time to Expiration	-0.28***	-0.28***	0.27***	0.27***	-0.14***	-0.14***	-1.06***	-1.06***
	(-8.19)	(-8.18)	(8.82)	(8.75)	(-5.52)	(-5.51)	(-42.66)	(-42.63)
K/S	15.04***	15.25***	16.57***	16.92***	32.27***	32.50***	12.77***	12.82***
	(13.74)	(13.89)	(16.02)	(16.30)	(14.33)	(14.41)	(19.40)	(19.45)

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	90-71 days		70-51 days		50-31 days		30-11 days	
StockRet(-1)	0.14	0.18	-0.78***	-0.68***	-2.16***	-2.15***	-2.17***	-2.16***
	(0.58)	(0.72)	(-3.74)	(-3.22)	(-12.76)	(-12.65)	(-12.47)	(-12.36)
StockRet(-2)	-0.05	-0.13	-1.11***	-1.24***	-1.41***	-1.42***	-1.51***	-1.54***
	(-0.20)	(-0.52)	(-4.99)	(-5.51)	(-8.00)	(-7.98)	(-8.49)	(-8.61)
StockRet(-3)	-0.03	-0.10	-1.09***	-1.15***	-1.22***	-1.23***	-1.51***	-1.54***
	(-0.12)	(-0.40)	(-4.97)	(-5.23)	(-7.15)	(-7.15)	(-8.76)	(-8.88)
StockRet(-4)	-0.10	-0.16	-0.68***	-0.76***	-0.42**	-0.44**	-0.65***	-0.67***
	(-0.42)	(-0.65)	(-3.23)	(-3.60)	(-2.51)	(-2.57)	(-3.83)	(-3.93)
StockRet(-19,-5)	0.34	0.27	0.53	0.46	0.42	0.38	-0.62**	-0.64**
	(0.80)	(0.62)	(1.37)	(1.19)	(1.36)	(1.22)	(-1.99)	(-2.05)
StockRetVar(-19,-5)	-0.88	-1.07	-0.10	-0.28	-2.24**	-2.25**	-2.92***	-3.02***
	(-1.07)	(-1.29)	(-0.26)	(-0.76)	(-2.31)	(-2.32)	(-4.33)	(-4.47)
MktCap	27.11***	27.78***	15.08	14.32	8.78	8.48	20.12***	20.32***
	(5.02)	(5.14)	(1.02)	(0.97)	(1.00)	(0.97)	(4.63)	(4.68)
B/M	-0.85	-1.35	-9.67	-9.08	0.29	0.49	-4.85	-4.92
	(-0.22)	(-0.35)	(-1.17)	(-1.10)	(0.08)	(0.14)	(-1.29)	(-1.31)
Momentum	-1.31	-1.30	0.63	0.56	0.29	0.32	-0.56	-0.54
	(-1.15)	(-1.14)	(0.28)	(0.24)	(0.16)	(0.18)	(-1.00)	(-0.96)
Turnover	-1.02	-1.22	-1.03	-0.58	-5.47	-5.69	-6.02*	-5.96*
	(-0.28)	(-0.33)	(-0.09)	(-0.05)	(-0.78)	(-0.81)	(-1.78)	(-1.76)
Expiration Friday	-1.21	-1.25	-0.33	-0.34	-1.12**	-1.13**	-5.66***	-5.69***
	(-0.79)	(-0.82)	(-0.45)	(-0.46)	(-2.19)	(-2.20)	(-4.42)	(-4.44)
N	181,827	181,827	237,634	237,634	341,215	341,215	375,552	375,552

Table 4: Tax Loss Selling

This table tests whether the disposition effect and role of volatility are driven by a tax loss selling effect by examining the January and February-December subsamples separately. The dependent variable is sell-buy imbalance, *Sell-Buy IMB*. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). *XLoss* is a dummy variable which equals one if the option is in the lowest decile of *CGO* in its time to expiration subsample. *XGain* is a dummy variable which equals one if the option is in the highest decile of *CGO* in its time to expiration group. Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *CGO* × *StockIvol*, *XLoss* × *StockIvol*, and *XGain* × *StockIvol* are interaction terms. Panel A reports the results for calls (A.1 is January, A.2 is February-December), while Panel B does so for puts (B.1 is January, B.2 is February-December). All specifications include the full set of control variables in Table 3. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A.1: Calls, January

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	3.72***	3.25**	1.92**	5.15***	1.67	3.95***	0.43	-1.15
	(3.56)	(2.06)	(1.97)	(2.89)	(1.61)	(2.58)	(0.47)	(-0.75)
XLoss	3.78	4.33	1.28	5.34	6.07*	7.90	5.50**	-0.18
	(1.61)	(0.86)	(0.57)	(1.02)	(1.91)	(1.29)	(2.08)	(-0.03)
CGO × StockIvol		0.71		-4.57**		-3.37*		3.23
		(0.39)		(-2.17)		(-1.93)		(1.29)
XLoss × StockIvol		-0.22		-1.74		-0.75		2.59
		(-0.12)		(-0.84)		(-0.38)		(1.18)
StockIvol	3.25*	3.23*	-1.11	-0.94	1.19	0.86	6.03***	5.71**
	(1.87)	(1.81)	(-0.66)	(-0.55)	(0.65)	(0.45)	(2.58)	(2.41)
					Controls Included			
N	39,020	39,020	34,346	34,346	30,962	30,962	38,625	38,625

Panel A.2: Calls, February-December

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	1.10***	2.43***	2.08***	4.00***	1.70***	3.08***	0.86***	1.78***
	(3.33)	(5.10)	(6.94)	(8.97)	(6.79)	(8.18)	(3.40)	(4.61)
XLoss	2.15***	3.27**	4.31***	8.20***	3.10***	7.89***	2.17***	3.86***
	(2.66)	(2.14)	(5.78)	(5.63)	(4.72)	(6.13)	(3.17)	(2.90)
CGO × StockIvol		-2.60***		-3.41***		-2.57***		-1.91***
		(-3.81)		(-5.79)		(-4.96)		(-3.15)
XLoss × StockIvol		-0.56		-1.76***		-2.21***		-0.85
		(-0.89)		(-3.16)		(-4.34)		(-1.52)
StockIvol	0.88	0.90	0.36	0.63	2.35***	2.90***	1.84***	2.00***
	(1.56)	(1.54)	(0.75)	(1.26)	(4.80)	(5.76)	(3.62)	(3.86)
					Controls Included			
N	343,744	343,744	400,599	400,599	497,188	497,188	486,491	486,491

Panel B.1: Puts, January

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	1.58	1.64	1.26	-1.16	-2.12	-5.32***	0.09	-1.15
	(1.07)	(0.73)	(0.92)	(-0.48)	(-1.64)	(-2.89)	(0.08)	(-0.77)
XGain	5.51	-4.40	1.26	-0.50	6.71**	12.67**	-2.17	-1.34
	(1.45)	(-0.69)	(0.41)	(-0.07)	(2.05)	(2.18)	(-0.75)	(-0.27)
CGO × StockIvol		0.10		3.22		5.24**		2.76
		(0.04)		(1.20)		(2.42)		(1.24)
XGain × StockIvol		3.61		0.61		-2.58		-0.35
		(1.93)		(0.27)		(-1.23)		(-0.21)
StockIvol	-3.57	-5.41*	2.61	2.82	-0.60	0.36	2.60	2.82
	(-1.23)	(-1.80)	(1.08)	(1.13)	(-0.22)	(0.13)	(0.84)	(0.91)
					Controls Included			
N	18,396	18,396	16,950	16,950	17,761	17,761	25,432	25,432

Panel B.2: Puts, February-December

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	-0.90*	-1.79***	-1.03***	-2.44***	-0.90***	-1.47***	-0.35	-0.38
	(-1.90)	(-2.80)	(-2.58)	(-4.20)	(-3.01)	(-3.40)	(-1.24)	(-0.86)
XGain	2.14**	1.57	1.25	0.75	0.87	2.67**	1.67**	0.70
	(2.16)	(0.90)	(1.44)	(0.47)	(1.25)	(2.12)	(2.45)	(0.53)
CGO × StockIvol		1.59**		2.39***		1.07*		0.04
		(2.01)		(3.27)		(1.85)		(0.06)
XGain × StockIvol		0.28		0.24		-0.81*		0.43
		(0.39)		(0.41)		(-1.71)		(0.86)
StockIvol	0.80	0.86	1.10*	1.28*	2.09***	2.37***	2.21***	2.11***
	(0.90)	(0.93)	(1.70)	(1.88)	(3.22)	(3.56)	(3.47)	(3.23)
					Controls Included			
N	163,431	163,431	220,684	220,684	323,454	323,454	350,120	350,120

Table 5: Robustness

This table tests whether the disposition effect and role of volatility are robust to alternative specifications of capital gains overhang. Panel A reports the results for calls, while Panel B does so for puts. The dependent variable is sell-buy imbalance, *Sell-Buy IMB*. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). In Panel A.1 and B.1, *CGO Gain* is equal to *CGO* if *CGO* is greater than zero and is equal to zero otherwise. *CGO Loss* is equal to *CGO* if *CGO* is less than zero and is equal to zero otherwise. *CGO* is the stock's capital gains overhang as defined in equation (2). In Panel A.2 and B.2, *OCGO* is option capital gains overhang, calculated using the same methodology as in equations (2) except we use option prices rather than underlying stock prices in equation (3). *OXLoss* is a dummy variable which equals one if the option is in the lowest decile of *OCGO* in its time to expiration subsample. All specifications include the full set of control variables in Table 3. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A.1: Calls, *CGOGain* and *CGOLoss*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGOGain	1.33***	2.11***	2.03***	3.56***	1.69***	3.08***	1.09***	1.88***
	(5.73)	(5.98)	(9.59)	(10.74)	(8.97)	(10.70)	(5.74)	(6.20)
CGOLoss	0.05	0.51	-0.10	0.01	0.00	-0.50	-0.43**	-0.39
	(0.22)	(1.37)	(-0.41)	(0.04)	(0.02)	(-1.57)	(-2.09)	(-1.25)
CGOGain × StockIvol		-1.41***		-2.63***		-2.34***		-1.50***
		(-3.08)		(-6.09)		(-6.40)		(-3.38)
CGOLoss × StockIvol		-0.96*		-0.30		0.96**		-0.09
		(-1.71)		(-0.60)		(2.00)		(-0.18)
StockIvol	1.05**	1.37**	0.16	1.02**	2.40***	3.56***	1.88***	2.33***
	(2.02)	(2.39)	(0.34)	(1.98)	(5.11)	(6.96)	(3.85)	(4.47)
					Controls Included			
N	382,764	382,764	434,945	434,945	528,150	528,150	525,116	525,116

Panel A.2: Calls, *OCGO* and *OXLoss*

	90-71 days		70-51 days		50-31 days		30-11 days	
OCGO	0.83***	1.86***	0.92***	1.86***	1.28***	1.40***	1.82***	3.06***
	(3.03)	(4.29)	(3.35)	(4.13)	(5.12)	(3.36)	(6.35)	(6.02)
OXLoss	2.84***	1.85	1.65***	0.46	2.17***	2.21**	1.96***	0.90
	(4.23)	(1.63)	(2.59)	(0.42)	(3.69)	(2.13)	(3.00)	(0.73)
OCGO × StockIvol		-1.33**		-1.13*		-0.05		-1.73**
		(-1.96)		(-1.95)		(-0.09)		(-2.24)
OXLoss × StockIvol		0.40		0.53		-0.08		0.66
		(0.82)		(1.23)		(-0.19)		(1.14)
StockIvol	1.12**	0.67	0.70	0.40	2.79***	2.81***	2.37***	1.90***
	(2.11)	(1.24)	(1.47)	(0.82)	(5.84)	(5.81)	(4.63)	(3.66)
					Controls Included			
N	380,851	380,851	432,606	432,606	524,281	524,281	519,953	519,953

Panel B.1: Puts, *CGOGain* and *CGOLoss*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGOGain	0.34	-0.33	-0.23	-0.88*	0.08	0.59	0.32	0.20
	(0.98)	(-0.67)	(-0.80)	(-1.93)	(0.35)	(1.64)	(1.43)	(0.53)
CGOLoss	-0.52	-1.16**	-0.57	-1.84***	-0.95	-1.89***	-0.38	-0.82***
	(-1.36)	(-2.09)	(-1.64)	(-3.41)	(-3.63)	(-4.73)	(-1.51)	(-2.03)
CGOGain × StockIvol		1.22**		1.18**		-0.77*		0.23
		(1.99)		(2.04)		(-1.77)		(0.47)
CGOLoss × StockIvol		1.24		2.26***		1.83***		0.94
		(1.64)		(3.13)		(3.11)		(1.40)
StockIvol	0.07	-0.09	1.20*	1.42**	1.86***	2.50***	2.01***	2.15***
	(0.09)	(-0.10)	(1.93)	(2.06)	(2.98)	(3.76)	(3.29)	(3.30)
					Controls Included			
N	181,827	181,827	237,634	237,634	341,215	341,215	375,552	375,552

Panel B.2: Puts, *OCGO* and *OXLoss*

	90-71 days		70-51 days		50-31 days		30-11 days	
OCGO	0.40	1.18**	0.67**	1.91***	0.56*	1.67***	1.06***	1.42**
	(1.11)	(2.26)	(1.98)	(3.54)	(1.95)	(3.60)	(3.40)	(2.53)
OXLoss	-1.30	-1.19	-1.68**	-1.90	-2.67***	-5.08***	-3.21***	-3.60***
	(-1.44)	(-0.86)	(-2.09)	(-1.38)	(-4.00)	(-4.48)	(-4.58)	(-2.69)
OCGO × StockIvol		-1.09		-1.32**		-1.42***		-0.26
		(-1.40)		(-2.19)		(-2.65)		(-0.35)
OXLoss × StockIvol		-0.20		0.01		2.11***		0.32
		(-0.23)		(0.01)		(2.64)		(0.30)
StockIvol	0.34	0.34	1.41**	1.35	2.10***	0.21	1.74***	1.77
	(0.41)	(0.30)	(2.18)	(1.28)	(3.31)	(0.21)	(2.76)	(1.46)
					Controls Included			
N	181,047	181,047	236,559	236,559	338,923	338,923	371,543	371,543

Table 6: Customer vs. Firm Sell-Buy Imbalance

This table tests whether the disposition effect and role of volatility differ for customers vs. firms as classified by ISE trading volume. Panel A reports the results for calls, while Panel B does so for puts. In Panels A.1 and B.1, the dependent variable is *Customer Sell-Buy IMB*, calculated as the sell-buy imbalance as defined in equation (1) solely for customer traders. In Panels A.2 and B.2, the dependent variable is *Firm Sell-Buy IMB*, calculated as firm traders' sell-buy imbalance. In Panel A.3 and B.3, the dependent variable is *Customer – Firm Sell-Buy IMB*, calculated as the difference between the sell-buy imbalance of both types of traders. *CGO* is the stock's capital gains overhang as defined in equation (2). *XLoss* is a dummy variable which equals one if the option is in the lowest decile of *CGO* for each time to expiration group (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration). *XGain* is a dummy variable which equals one if the option is in the highest decile of *CGO* in its time to expiration subsample. Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *CGO* × *StockIvol*, *XLoss* × *StockIvol*, and *XGain* × *StockIvol* are interaction terms. All specifications include the full set of control variables in Table 3. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A.1: Calls, *Customer Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	1.18***	2.44***	2.15***	4.46***	1.57***	3.01***	0.45*	1.05***
	(3.93)	(5.60)	(7.65)	(10.52)	(6.56)	(8.35)	(1.86)	(2.86)
XLoss	2.85***	2.98**	4.24***	8.36***	3.81***	7.56***	3.04***	4.33***
	(3.89)	(2.12)	(6.11)	(6.08)	(6.02)	(6.10)	(4.67)	(3.41)
CGO × StockIvol		-2.37***		-4.01***		-2.63***		-1.25**
		(-3.87)		(-7.23)		(-5.35)		(-2.17)
XLoss × StockIvol		-0.08		-1.86***		-1.71***		-0.64
		(-0.13)		(-3.52)		(-3.54)		(-1.21)
StockIvol	0.96*	0.91*	0.52	0.77*	2.59***	3.03***	2.26***	2.38***
	(1.89)	(1.73)	(1.15)	(1.65)	(5.59)	(6.34)	(4.69)	(4.83)
				Controls Included				
N	382,764	382,764	434,945	434,945	528,150	528,150	525,116	525,116

Panel A.2: Calls, *Firm Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	0.26*	0.06	-0.01	-0.14	0.35**	0.57***	0.55***	1.01***
	(1.74)	(0.28)	(-0.07)	(-0.62)	(2.57)	(2.80)	(3.60)	(4.36)
XLoss	-0.28	0.26	-0.01	0.84	0.15	1.52**	-0.16	1.08
	(-0.76)	(0.37)	(-0.04)	(1.17)	(0.40)	(2.17)	(-0.38)	(1.34)
CGO × StockIvol		0.37		0.20		-0.42		-0.97***
		(1.20)		(0.70)		(-1.52)		(-2.65)
XLoss × StockIvol		-0.26		-0.37		-0.63**		-0.61*
		(-0.89)		(-1.36)		(-2.28)		(-1.82)
StockIvol	0.54**	0.62**	0.20	0.31	0.92***	1.06***	0.95***	1.07***
	(2.11)	(2.33)	(0.84)	(1.27)	(3.49)	(3.93)	(3.12)	(3.42)
					Controls Included			
N	382,764	382,764	434,945	434,945	528,150	528,150	525,116	525,116

Panel A.3: Calls, *Customer - Firm Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	0.92***	2.38***	2.16***	4.60***	1.22***	2.44***	-0.10	0.03
	(2.67)	(4.77)	(6.68)	(9.42)	(4.35)	(5.77)	(-0.35)	(0.08)
XLoss	3.14***	2.71*	4.25***	7.52***	3.67***	6.04***	3.20***	3.25**
	(3.73)	(1.69)	(5.33)	(4.75)	(4.93)	(4.15)	(4.05)	(2.11)
CGO × StockIvol		-2.74***		-4.22***		-2.21***		-0.28
		(-3.91)		(-6.60)		(-3.83)		(-0.40)
XLoss × StockIvol		0.18		-1.48**		-1.09*		-0.03
		(0.28)		(-2.44)		(-1.92)		(-0.05)
StockIvol	0.42	0.29	0.32	0.46	1.68***	1.97***	1.31**	1.31**
	(0.72)	(0.48)	(0.62)	(0.86)	(3.08)	(3.51)	(2.24)	(2.20)
					Controls Included			
N	382,764	382,764	434,945	434,945	528,150	528,150	525,116	525,116

Panel B.1: Puts, *Customer Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	0.04	-0.62	-0.67*	-2.28***	-0.65**	-1.43***	-0.56**	-0.89**
	(0.09)	(-1.07)	(-1.82)	(-4.19)	(-2.30)	(-3.49)	(-2.11)	(-2.15)
XGain	1.38	-0.39	1.47*	1.13	0.99	3.20***	2.48***	1.85
	(1.52)	(-0.25)	(1.82)	(0.76)	(1.51)	(2.66)	(3.83)	(1.49)
CGO × StockIvol		1.11		2.69***		1.46***		0.62
		(1.58)		(3.97)		(2.67)		(0.99)
XGain × StockIvol		0.83		0.16		-0.98**		0.28
		(1.35)		(0.29)		(-2.19)		(0.59)
StockIvol	0.42	0.18	1.19**	1.43**	1.80***	2.15***	2.24***	2.24***
	(0.53)	(0.21)	(1.99)	(2.26)	(2.94)	(3.41)	(3.74)	(3.62)
				Controls Included				
N	181,827	181,827	237,634	237,634	341,215	341,215	375,552	375,552

Panel B.2: Puts, *Firm Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	-0.55**	-0.76**	-0.44**	-0.55*	-0.45***	-0.42*	0.16	0.09
	(-2.35)	(-2.38)	(-2.14)	(-1.83)	(-2.74)	(-1.78)	(0.92)	(0.34)
XGain	0.93*	1.03	-0.06	-0.18	0.39	0.31	-0.93**	-0.14
	(1.84)	(1.16)	(-0.14)	(-0.21)	(1.01)	(0.44)	(-2.26)	(-0.18)
CGO × StockIvol		0.37		0.19		-0.05		0.14
		(0.95)		(0.50)		(-0.17)		(0.35)
XGain × StockIvol		-0.05		0.05		0.04		-0.35
		(-0.14)		(0.17)		(0.13)		(-1.17)
StockIvol	0.73*	0.77*	0.35	0.36	1.03***	1.02***	1.72***	1.82***
	(1.68)	(1.68)	(1.06)	(1.02)	(2.90)	(2.79)	(4.53)	(4.64)
				Controls Included				
N	181,827	181,827	237,634	237,634	341,215	341,215	375,552	375,552

Panel B.3: Puts, *Customer - Firm Sell-Buy IMB*

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	0.59	0.15	-0.23	-1.72***	-0.20	-1.01**	-0.72**	-0.98**
	(1.20)	(0.22)	(-0.53)	(-2.72)	(-0.60)	(-2.09)	(-2.24)	(-1.96)
XGain	0.45	-1.42	1.53	1.31	0.60	2.89**	3.41***	1.99
	(0.42)	(-0.77)	(1.63)	(0.75)	(0.78)	(2.04)	(4.36)	(1.33)
CGO × StockIvol		0.74		2.50***		1.51**		0.48
		(0.90)		(3.16)		(2.35)		(0.64)
XGain × StockIvol		0.88		0.11		-1.02*		0.63
		(1.22)		(0.17)		(-1.92)		(1.11)
StockIvol	-0.32	-0.59	0.84	1.07	0.77	1.13	0.52	0.42
	(-0.35)	(-0.62)	(1.20)	(1.45)	(1.06)	(1.52)	(0.71)	(0.56)
					Controls Included			
N	181,827	181,827	237,634	237,634	341,215	341,215	375,552	375,552

Table 7: Delta Hedged Returns

This table tests whether the disposition effect and role of volatility on day_t influence delta-hedged returns on day_{t+1}. Panel A reports the results for calls, while Panel B does so for puts. The dependent variable is *D-HRet*, the delta hedged dollar option return on day_{t+1} scaled by option price on day_t. *CGO* is the stock's capital gains overhang. *CGO* is the stock's capital gains overhang as defined in equation (2). *XLoss* is a dummy variable which equals one if the option is in the lowest decile of *CGO* in its time to expiration subsample (90-71 days, 70-51 days, 50-31 days, and 30-11 days to expiration). *XGain* is a dummy variable which equals one if the option is in the highest decile of *CGO* in its time to expiration subsample. Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *CGO* × *StockIvol*, *XLoss* × *StockIvol*, and *XGain* × *StockIvol* are interaction terms. All specifications include the full set of control variables in Table 3. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

Panel A: Calls

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	0.33***	0.59***	0.30***	0.76***	0.56***	0.99***	0.30***	0.46***
	(6.73)	(8.15)	(6.27)	(10.41)	(9.13)	(10.56)	(3.79)	(3.77)
XLoss	-1.01***	-2.55***	-0.81***	-1.09***	-1.76***	-3.08***	-1.50***	-2.17***
	(-6.98)	(-9.15)	(-5.61)	(-3.73)	(-8.33)	(-7.31)	(-4.85)	(-3.62)
CGO × StockIvol		-0.36***		-0.67***		-0.61***		-0.23*
		(-4.71)		(-8.34)		(-6.08)		(-1.81)
XLoss × StockIvol		0.50***		0.07		0.38***		0.17
		(6.21)		(0.86)		(3.38)		(1.19)
StockIvol	-1.61***	-1.72***	-1.10***	-1.18***	-2.06***	-2.08***	-2.44***	-2.47***
	(-19.89)	(-20.60)	(-13.25)	(-13.80)	(-16.27)	(-15.95)	(-14.76)	(-14.62)
					Controls Included			
N	320,031	320,031	358,859	358,859	422,461	422,461	375,331	375,331

Panel B: Puts

	90-71 days		70-51 days		50-31 days		30-11 days	
CGO	-0.18**	-0.15	-0.16***	-0.19**	-0.67***	-0.87***	-0.67***	-1.26***
	(-2.31)	(-1.41)	(-2.93)	(-2.30)	(-7.01)	(-6.21)	(-5.56)	(-6.73)
XGain	-0.46**	-0.75**	-0.52***	-0.67**	0.31	0.43	-0.69*	0.07
	(-2.45)	(-2.23)	(-3.69)	(-2.51)	(1.18)	(0.88)	(-1.81)	(0.10)
CGO × StockIvol		-0.05		0.04		0.29*		0.83***
		(-0.42)		(0.43)		(1.91)		(4.12)
XGain × StockIvol		0.12		0.05		-0.05		-0.26
		(1.03)		(0.65)		(-0.32)		(-1.24)
StockIvol	-1.82***	-1.86***	-1.16***	-1.17***	-1.87***	-1.85***	-2.86***	-2.69***
	(-13.10)	(-12.81)	(-12.38)	(-11.92)	(-9.22)	(-8.90)	(-10.58)	(-9.72)
					Controls Included			
N	151,187	151,187	196,826	196,826	270,827	270,827	255,196	255,196

Table 8: Stock Returns

This table tests whether the disposition effect in option trading and role of volatility on day_t leads to predictable stock returns on day_{t+1}. The dependent variable is *MMStockRet* or FFStockRet, the abnormal stock returns on day_{t+1} using the market model and Fama-French four factor model, respectively. *CGODiff* is the difference between the open-interest-weighted average *CGO* of calls and of puts on each stock. *CGO* is the stock's capital gains overhang as defined in equation (2). Stock idiosyncratic volatility (*StockIvol*) is the standard deviation of the residuals of the 20 days' returns regressed on the Fama-French three factors (Ang, Hodrick, Xing, and Zhang 2006). *CGODiff* × *StockIvol* is an interaction term. All specifications include stock characteristic control variables. Individual stock and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

	Stock MMRet		Stock FFRet	
CGODiff	0.00	-0.03***	0.00	-0.03***
	(0.71)	(-3.72)	(0.44)	(-4.33)
CGODiff × StockIvol		0.04***		0.05***
		(5.63)		(6.21)
StockIvol	0.06***	0.06***	0.06***	0.06***
	(6.02)	(6.04)	(5.88)	(5.91)
	Stock-level Controls Included			
N	379,234	379,234	379,234	379,234

Appendix

Table A.1: CGO Decile Averages

This table reports the average CGO value by CGO decile. *CGO* is the stock's capital gains overhang as defined in equation (2). The sample period is from May 2005 to August 2014.

	Calls				Puts			
CGO Decile	**90-71 days**	**70-51 days**	**50-31 days**	**30-11 days**	**90-71 days**	**70-51 days**	**50-31 days**	**30-11 days**
1	-16.32	-16.41	-14.87	-14.63	-14.95	-15.00	-14.15	-13.73
2	-5.65	-5.41	-4.67	-4.45	-5.00	-4.92	-4.40	-4.17
3	-3.08	-2.93	-2.51	-2.37	-2.74	-2.69	-2.37	-2.24
4	-1.59	-1.52	-1.28	-1.21	-1.42	-1.39	-1.21	-1.14
5	-0.49	-0.47	-0.39	-0.37	-0.43	-0.43	-0.37	-0.35
6	0.50	0.44	0.39	0.37	0.47	0.44	0.41	0.38
7	1.53	1.36	1.22	1.16	1.43	1.35	1.25	1.17
8	2.77	2.48	2.25	2.15	2.60	2.46	2.28	2.15
9	4.65	4.20	3.88	3.71	4.35	4.15	3.87	3.67
10	10.07	9.48	9.05	8.76	9.48	9.17	8.90	8.57

Table A.2: Univariate Analysis of the Disposition Effect

This table presents a univariate analysis of the disposition effect in option trading. The sample is divided into four subsamples by time to expiration: 90-71 days, 70-51 days, 50-31 days, and 30-11 days. The dependent variable is sell-buy imbalance, *Sell-Buy IMB*. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

	Calls				Puts			
	90-71 days	70-51 days	50-31 days	30-11 days	90-71 days	70-51 days	50-31 days	30-11 days
CGO	1.41***	1.94***	1.49***	0.43***	-1.91***	-2.83***	-1.35***	-0.80***
	(7.62)	(10.83)	(9.81)	(3.02)	(-6.79)	(-11.16)	(-6.95)	(-4.53)
N	411,276	472,181	586,129	633,210	194,202	254,870	371,305	438,304

Table A.3: The Role of Implied Volatility

This table explores the role of implied volatility in option trading based on reference prices. The sample is divided into four subsamples by time to expiration: 90-71 days, 70-51 days, 50-31 days, and 30-11 days. The dependent variable is sell-buy imbalance, *Sell-Buy IMB*. *Sell-Buy IMB* is defined as current sell-buy imbalance minus average sell-buy imbalance for the option over the past 20 trading days, where sell-buy imbalance is defined in equation (1). *CGO* is the stock's capital gains overhang as defined in equation (2). *XLoss* is a dummy variable which equals one if the option is in the lowest decile of *CGO* in its time to expiration subsample. *XGain* is a dummy variable which equals one if the option is in the highest decile of *CGO* in its time to expiration group. *ImpliedVol* is implied volatility on day_{t-1}. *CGO* × *ImpliedVol*, *XLoss* × *ImpliedVol*, and *XGain* × *ImpliedVol* are interaction terms. All specifications include the full set of control variables in Table 3. Individual option and quarter fixed effects are included in all specifications. All coefficients are in percent. *, **, and *** indicate 10%, 5%, and 1% level of significance respectively using a two-tailed test. The *t*-statistics are reported in parentheses. The sample period is from May 2005 to August 2014.

	Calls				Puts			
	90-71 days	70-51 days	50-31 days	30-11 days	90-71 days	70-51 days	50-31 days	30-11 days
CGO × ImpliedVol	-3.78***	-3.23***	-3.14***	-2.17***	3.38***	4.75***	2.51***	2.15***
	(-6.74)	(-6.17)	(-7.29)	(-5.20)	(4.62)	(7.45)	(5.33)	(4.96)
XLoss × ImpliedVol	-1.73***	-1.95***	-2.59***	-0.76				
	(-3.01)	(-3.45)	(-5.69)	(-1.63)				
XGain × ImpliedVol					-0.45	-1.60***	-0.75	-1.02**
					(-0.62)	(-2.68)	(-1.54)	(-2.18)
CGO	4.49***	4.69***	4.36***	2.87***	-3.27***	-4.47***	-2.92***	-2.17***
	(8.14)	(9.16)	(10.08)	(6.11)	(-4.52)	(-7.26)	(-6.24)	(-4.74)
XLoss	7.40***	9.49***	10.71***	4.63***				
	(4.05)	(5.39)	(7.35)	(2.78)				
XGain					3.48	5.82***	3.15**	4.49***
					(1.60)	(3.12)	(2.10)	(2.97)
ImpliedVol	9.61***	10.69***	8.88***	3.39***	2.03	6.02***	4.68***	-0.81
	(10.08)	(12.24)	(13.96)	(7.66)	(1.34)	(5.13)	(5.22)	(-1.32)
				Controls Included				
N	382,764	434,945	528,150	525,116	181,827	237,634	341,215	375,552