Betting on Elusive Returns: Retail Trading in Complex Options

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March, 2023

Abstract

Retail trading in complex (multi-leg) options has grown significantly following the introduction of zero commissions by several brokerage firms. We show that the returns on these complex orders are negative on average (-16.4% over three-day holding periods), and that the higher the complexity, the lower the returns. We also find that a significant fraction (28%) of complex options trades are around firms' earnings announcements, and these trades lead to significant losses. Subjective volatility expectations from complex volatility options suggest that retail investors overestimate expected volatility during earnings announcements. Overall, our findings suggest that retail investors are playing a losing game by betting on complex options strategies because of their lottery-like payoffs.

Keywords: *Zero-commissions, Retail Investors, Complex Options, Earnings Announcement*
JEL Classification: *G14; G23; G24; G28*

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1. Introduction

Retail trading in options has grown substantially in recent years due to the introduction of zero-commissions offered by fintech apps such as Robinhood and other brokerages, greater work flexibility owing to Covid-19 disruptions, and increase in social media attention. According to the Options Clearing Corporation (OCC), on average, 39 million options contracts were traded daily in 2021, and the dollar trading volume in options grew by 143 percent from November 2019 to July 2021. Notably, complex (multi-leg) options trades accounted for nearly 20% of the retail options trades in July 2022.[1] While the reduction in commissions and ease of trading have reduced barriers to entry for retail investors and others, the significant rise in option (and equity) retail trading activity has raised concerns on the gamification of trading that encourages gambling rather than sensible investment decision making.[2] This concern is especially heightened in the case of complex options that are oversimplified on trading apps and that have different margin requirement than single-leg options, making it easy to lose money. Complex options trading provides a unique setting for understanding the effects of financial product complexity and risk shrouding on retail traders. Given this important context, we address the essential, yet unanswered, questions of what are the trading strategies of retail traders in complex options and their return performance?

[1]Based on both the largest U.S. retail brokerages reports under the SEC Rule 606 (routing of orders) for Robinhood and TD Ameritrade and the OPRA data where multileg option trade can be identified based on the trading conditions between 119 and 123. A complex option order is an order in which two or more different options series or legs are sent to be executed as a single order. For instance, a vertical spread complex order, one of the most popular complex options strategies in our sample, involves buying a call (put) with one strike price and simultaneously selling a call (put) with another strike price, with both options having the same expiration date. Such a combination yields different payoff structures that span different states (Ross (1976)).

[2]For example, in a speech on October 13, 2021, Rick Fleming, the Director of the Office of the Investor Advocate at the SEC, states "My primary concern with gamification is its potential to induce trading that is more frequent or higher-risk than an investor would choose for herself in the absence of DEPs." He describes gamification as the use of technological tools to make trading easier and more exciting. Broker-dealers and investment advisers often utilize various digital engagement practices (DEPs) to connect with a broader array of retail investors, particularly younger investors who grew up with similar design features in other online apps and games on their devices.

While options trading has existed for almost five decades, prior studies have focused on single-leg options, and little is known about investors' trading behavior and returns on complex options trades.[3] Trading options is viewed as inherently riskier than trading the underlying stock because of the complex risk/return payoff structure of the options and the embedded leverage in options. Complex options strategies additionally require investors to choose option legs from a large menu of option series. For example, in March 2021, Apple stock (AAPL) had 2,652 different options series with traded prices (17 different maturities and 156 exercise prices for call and put options). Given their complexity and shrouded inherent risks, complex options have generally been viewed as sophisticated strategies employed by hedge funds and other sophisticated investors to generate high Sharpe ratios and have limited participation. As such, complex options trading has only been allowed for customers who satisfy a minimum level of investment sophistication and financial liquidity as well as some additional approval paperwork from brokerages.

Importantly, the recent development of commission-free trading on simple and convenient interfaces such as Robinhood's platform, has lowered the barrier to not only investing in the stock market but also trading complex options.[4] While zero-commission equity trading for Robinhood users has existed since 2015, zero-commission trading for multi-leg options strategies was introduced in June 2018, where there is no commission and no per contract fee for buying or selling options, as well as no exercise or assignment fees.[5] In view

[3]Studies examining complex options mainly focus on hypothetical complex strategies and not on actual trades. For instance, Coval and Shumway (2001) examine the returns to a hypothetical at-the-money straddle, while Lakonishok et al. (2007) calculate an upper-bound for the trading volume of straddle/strangle strategies by assuming the minimum of the call and put option volumes that were traded at the same time.

[4]Brokers such as Robinhood have between three and five tiers for options trading based on the investors' trading experience, income, and risk profiles. For instance, a complex option strategy, such as an option spread, which involves using two option legs (one long and one short), is not available to most investors until they graduate to level 3. However, upgrading to level 3 requires only "answering 3 or 4 questions," following the template outlined in the Reddit forum such as in the following link:https://www.reddit.com/r/OptionsASAP/comments/mp5in6/how_to_get_level_3_options_on_robinhood/.

[5]See https://blog.robinhood.com/news/2018/6/12/introducing-multi-leg-options-strategies for the announcement. Option traders from other platforms pay up to $6.95 commission and $0.75 per contract and up to $19.99 upon exercising and assignment.

of the increased retail trader access, ease, and gamification of trading in complex options that shrouds their risks, it is important to understand the salient effects on retail trader choices and their performance.

We use retail trade-level data of multi-leg complex options from a major options exchange to examine the impact of zero-commission on retail complex options trades. First, the aggregated time series trend shows that the monthly aggregated dollar volume of complex options trading dramatically increased from $100 million in 2012 to a peak of $1.6 billion in the first quarter of 2020. To sharpen the identification, we conduct a difference-in-difference test to quantify the effect of zero-commission on complex options trades via the Robinhood platform on trading volumes and the complexity of trades by retail investors. We find that after the introduction of zero-commissions, complex options trades (volumes) favored by retail investors increase by more than 75.4% (43.5%) compared to options on other stocks. Furthermore, we find that retail investors increasingly use more sophisticated complex strategies (options with three or more legs) in the post-zero-commission period.

After establishing the effect of the introduction of zero-commission on complex options trades, we turn to examine the performance of these complex options trades by retail investors. Complex assets are generally viewed as sophisticated instruments that have attractive risk-return trade-offs and higher Sharpe ratios (Goetzmann et al. (2002), Carlin et al. (2013), Eisfeldt et al. (2022), Calvet et al. (2022)). On the one hand, sophisticated strategies with complex payoff structures require more intellectual and financial capital. They also have limited direct participation. As a result, expert investors can better exploit arbitrage opportunities to earn alpha in complex assets (Eisfeldt et al. (2022)) and use complex assets to mitigate behavioral biases to increase portfolio returns (Calvet et al. (2022)). On the other hand, complexity bounds retail investors' ability to accurately value assets, especially when attention is limited. The increased amount of information for complex options can lead to information overload, resulting in inferior investment and risk management decisions (Brunnermeier and Oehmke (2009)). Furthermore, the model from Eisfeldt et al. (2022) highlights that levels of investor expertise play a key role in driving the endogenously limited participation for complex assets and returns expectations. In other words, less expert investors face greater risk per unit of expected return. This is particularly true for retail investors such as Robinhood users. Half of the Robinhood investors are first-time investors who trade more frequently and have smaller account sizes than traditional retail brokerages. There has been evidence suggesting that Robinhood investors, on average, appear to behave as noise traders in equity markets and trade speculatively.[6]

We conjecture that the documented speculative behavior of retail traders should also extend to complex options trades. In this regard, we document that during our sample period, complex options purchased by retail investors had on average returns of -6.1%, -9.3%, and -11.1% over one-, two-, and three-day holding periods, respectively.[7] Taking into account the bid-ask spread when exiting the position, the returns further decrease to -12.6%, -14.9%, and -16.4%, respectively. In addition, the post-zero-commission regime is associated with larger losses in complex options and among stocks favored by retail investors. This evidence is consistent with the hypothesis that less sophisticated and overly confident retail investors lose money on trading complex options with shrouded risks. Furthermore, we find that given the same trading margin requirements, and the same trading objectives (i.e., directional betting or volatility betting), the more complex strategies

[6]For instance, Barber et al. (2022) find evidence that herding by Robinhood traders negatively predicts returns and Barber et al. (2021) find that aggregate retail order flow negatively predicts returns for a subset of stocks with high retail volume. Eaton et al. (2022b) also show that Robinhood investors on average are uninformed about future stock returns. On the other hand, Welch (2022) shows that aggregate retail investors did well during the period of mid-2018 to mid-2020 and had both good timing and good alpha.

[7]To calculate the holding-horizon returns, we focus on the open positions only and assume the return of a complex option trade is based on a simple buy-and-hold strategy. The terminal value of a complex option is a combination of the payoff for each individual leg if the investor sells each component of the complex option at the closing price and the initial purchase price or premium received is cash flow at transaction time. We take into consideration the differences in the margin requirements for different complex strategies following the CFTC margin requirement books(https://cdn.cboe.com/resources/membership/Margin_Manual.pdf). More details are provided in Section 3.2.

that are used by retail investors yield, on average, lower returns compared to the relatively simple strategies.

While we clearly show that retail traders experience significant losses in complex options trading, what are their complex options strategy choices? We find that retail investors favor highly volatile, large-cap stocks, and stocks that are liquid with a high turnover. In addition, retail investors favor the complex options strategies with special margin requirements with higher embedded leverage; that is, strategies under the CFTC margin requirements need significantly less capital if two or more legs are purchased simultaneously. For instance, we find that the most popular strategies are vertical spreads and calendar spreads, where the margin requirement is the strike price difference rather than the margin requirement from one of the short options linked to the price of underlying securities. The popularity of such strategies suggests that retail investors not only trade fractional shares offered by brokerages (Da et al. (2022) and Bartlett et al. (2022)), but they also utilize complex strategies for such leverage. Finally, consistent with the attention-induced trading behavior documented by Barber et al. (2022), we find that retail investors trade more complex options on stocks with more extreme positive and negative returns.

Earnings announcements are one of the most salient and attention-grabbing events in financial markets, so it is important to also understand retail trading in complex options around these announcements. We show that complex options trading is elevated around earnings announcements; the trading volume from $t-2$ to $t+1$ ($t = 0$ is the announcement date) accounts for more than 12% to 28% of the total trading volume. This applies to both the directional and volatility betting strategies. Furthermore, the performance of the complex options strategies around earnings announcements is worse compared to the magnitude of returns for the strategies from the full sample.

To shed light on the sources of underperformance from complex options trading, we explore the subjective beliefs implied by volatility-based complex options around earnings announcements. Expectations about returns and volatility have important implications for asset pricing ((Greenwood and Shleifer, 2014; Lochstoer and Muir, 2022)). The granular trade data on the complex options trades allow us to directly examine the ex-ante expectations of volatility around earnings announcements, rather than relying on the risk-neutral implied volatility from hypothetical at-the-money straddle strategies. By comparing the ex-ante volatility to the realized volatility around earnings announcements, we find that retail investors consistently overestimate uncertainty, regardless of whether the volatility strategies are straddles, strangles, butterflys, or iron-condors.

Our study makes several contributions to the literature. First, we contribute to the growing literature on complex securities, structured products, and their shrouded risks. Célérier and Vallée (2017) show that banks design complex financial products (retail structured products) to cater to yield-seeking investors. Célérier and Vallée (2017) find that "... product headline rates depart from the prevailing interest rates as the latter decrease, complexity increases, and risky products become more common. Financial complexity is a by-product of banks catering to yield-seeking investors." Similarly, Henderson and Pearson (2011) examine 64 popular structured products and find that banks overprice these products by nearly 8%. Studies on complex retail structured products mainly emphasize the supply side of complex security, whereby banks tailor securities to improve risk sharing (Gale and Allen (1994); Duffie and Rahi (1995)), and cater to yield-seeking investors by shrouding risk (Bordalo et al. (2016)). Our study provides evidence on the demand side of complex financial securities, which retail investors synthesize by constructing from simple options, and the poor performance outcomes from those choices. We show that the ease of trading in complex options with shrouded risks increases speculative demand in securities with lottery like payoffs. The poor retail trader performance we find is in contrast to Welch (2022) who shows that retail investors did well in equity markets. This difference highlights the importance of the factors such as financial complexity and risk shrouding, which are more pronounced in our setting, in retail trader choices, performance, and welfare.

Second, we contribute to the literature on retail trading in options markets. Option traders are traditionally viewed as sophisticated, and several studies provide theoretical and empirical evidence of informed trading in options markets.[8] More recently, Bryzgalova et al. (2022) characterize retail option trading using the new flag from OPRA transaction-level data as a proxy for retail option trading and find evidence that retail investors sub-optimally leave open calls on cum-dividend dates, and de Silva et al. (2022) find evidence that retail options traders herd into options for stocks with upcoming earnings announcements, resulting in losses and wealth transfers to market makers. Eaton et al. (2022a) examines the impact of retail option trades on the implied volatility surface. However, prior studies have only examined single-leg options. Lakonishok et al. (2007) calculate the up-bound trading volume of straddle/strangle, strategies by assuming the minimum trades that traded at the same time. They document the equity options market activity by different classes of investors from 1990 to 2001. They find that volatility trading strategies account for only a small fraction of the overall options trading activity, suggesting that the primary motivations for trading equity options for end-users are hedging or speculating underlying stock price movements.

Our study focuses on complex options transactions by retail investors, and to the best of our knowledge, this is the first study to examine returns to complex options transactions by retail investors based on transaction prices. We find that retail traders are also attracted to options and complex options due to the easiness of the platform, reductions or eliminations of trading commissions, increased social media attention, and lottery-like payoffs. Ernst

[8] Investors use options to trade on not only directional information ((Stephan and Whaley (1990); Amin and Lee (1997); Easley et al. (1998), Chan et al. (2002), Chakravarty et al. (2004), Cao et al. (2005), and Pan and Poteshman (2006)) but also volatility information (Ni et al. (2008)).

and Spatt (2022) highlight that retail broker payments for order flow are much larger for options than stocks, which creates incentives for retail brokers to encourage option trading.

The remainder of this paper is organized as follows. Section 2 describes the data used in the study. In Section 3, we document the impact of zero-commission on the retail trading of complex options. Section 4 examines the performance of complex trades by retail investors. Section 5 explores the determinants of the complex options trade. Section 6 examines the relationship between complexity and returns. Section 7 focuses on complex trades around earnings announcements, and Section 8 presents the subjective volatility from these trades. Finally, Section 9 concludes.

2. Data and Descriptive Statistics

In this study, we use investor complex options trading data from one of the major exchanges in the U.S. This exchange accounts for approximately 15% of the entire U.S. options market volume. The transaction data contain detailed trade information including that on the trade time, number of contracts per order, transaction price, expiration date(s), strike prices, number of trades for every leg of each complex order and whether each leg is to buy to open, sell to open, buy to close, and sell to close. We proxy for individual investors using trades from non-professional customers in a manner similar to de Silva et al. (2022). In addition, we use the daily option end-of-day bid and ask prices from OptionMetrics to calculate the holding period returns for complex options strategies. The CRSP data are used for all stock-level information such as stock prices, returns, market capitalization, and realized volatility using daily returns. We focus on both common stocks and exchange traded funds in our main analysis. For earnings-related information, we use the institutional Brokers' Estimate System (I/B/E/S). The data covers the period between January, 2012, and December, 2021.

[INSERT FIGURE 1]

Figure 1 presents the time series of total dollar volume trades for complex options. The monthly aggregated dollar volume of complex options trading in 2012 was $ 100 million for all options. The trading volumes reached a peak in the first quarter of 2020 at $ 1.6 billion. Afterward, the complex options trades dropped but remained at $ 800 million toward the end of our sample. This general pattern is consistent with the patterns for equity trading by retail investors (Boehmer et al., 2021) and single-leg option trading by retail investors (Bryzgalova et al., 2022). Robinhood introduced zero-commissions for multileg options in June 2018, while other platforms (Fidelity, Interactive Brokers) introduced zero-commissions in October 2019[9] and it shows that the widespread adoption of zero commissions coincides with the increase of complex options trades. Classifying trades by complexity based on the number of legs involved shows a similar time series pattern (not reported).

Panel A in Table 1 provides summary statistics for the data used in this study, across trade-level observations. The key variables in our analyses are returns on capital over certain horizons. Dollar Premium represents the average dollar premium per trade. Consistent with the fact that retail investors trade small size and with limited capital, the number of contracts per order is 8.67, while the median number is 2. The average (median) number of dollar premiums for trade is $5,136 ($324), suggesting that there are a few large size trades whereas the majority of trades is small-size. Approximately 51% of trades are established by paying the premium by retail investors, while for the other 49% of the trades, retail investors receive credit from placing the complex trades.[10] The average days-to-maturity is 56, while 25% of the trades have a maturity of less than seven days, suggesting that

[9]Different from equity trading, all charge a per-contract fee for options trades, which is $0.65 per contract.

[10]The terminology is different from trading single-leg options, where credit means selling options and debit means buying options, and retail investors can create complex options such that the net payout could be negative or positive.

retail investors favor short-dated options. The returns on capital are, on average, negative, ranging from -1.80% for a one-day holding period, to -2.06% for a three-day holding period. The skewness of the returns is high at 31.53% over a 3-day holding period, consistent with the likelihood of a large positive payoff. Panels B, C, and D show the summary statistics for complex trades with two, three, and four legs, respectively. The patterns are similar across contract volume, maturity, and holding returns.

3. Empirical Results

3.1. Zero-commission and complex options trading

In this section, we examine the impact of zero-commission on complex options trading by retail investors. The time series trend suggests that complex options trades by retail investors have dramatically increased in recent years. This is consistent with the fact that trading platforms such as Robinhood and TD Ameritrade offer zero-commission for trading and provide easy-to-implement interfaces for complex options trading (See Figures Appendix). To formally test the hypothesis that retail investors trade more complex options after zero commissions are adopted, we estimate the following model:

$$\text{Volumes}_{i,t} = \alpha + \beta_1 \,\text{Post} \times \text{Retail}_i + \gamma_i + \delta_s + \varepsilon_{i,t} \tag{1}$$

where $\text{Volumes}_{i,t}$ represents the aggregate trades or trading volumes in natural logarithm for stock *i* in month *t*, and Post is a dummy variable that equals one if the observation is after the zero commission and zero otherwise. Retail is a dummy variable equal to 1 if the stock i is the top quintile of Robinhood ownership based on the number of stock owners at the time of June 2018. We control for both firm fixed effect and month fixed effect, and all standard errors are adjusted for heteroskedasticity and within-cluster correlations at both the firm and month levels.

[INSERT TABLE 2]

The results are presented in Table 2. Columns (1) and (2) report the aggregate trades and aggregate contract volumes for all complex options trades, respectively. The coefficients on the interaction term are statistically and economically significant: after the zero-commission regime, complex options trades favored by retail investors increase more than 75.4% (100*(exp(0.562)-1) %). Similarly, for aggregate contract volumes, the increase is 43.48%. The remaining columns in Table 2 report the coefficient estimates from the same regression for complex options with two-legs, three-legs, and four-legs or more. The results are similar and the relative increase in trades is slightly larger for complex options with more legs involved. Overall, the empirical evidence suggests that after zero-commission, retail investors trade more complex options, especially among stocks that are favored by retail investors.

3.2. Performance of complex option trading

The preceding evidence suggests that retail investors trade more complex options after the introduction of zero-commission. In this section, we examine the performance of complex options trades by retail investors. We focus on the open positions only and calculate returns of a complex option trade based on a simple buy-and-hold strategy. This strategy calculates returns on capital for an investor who trades a multi-leg complex option to establish the position and holds the position for one-day, two-day, and three-day after the purchase date. The investor sells each component of the complex options at the closing price. If any leg of the options has a maturity less than the holding horizon, we assume that the option will be exercised if it is in the money and calculate that leg's terminal pay-off based on whether the option is in the money and the price difference between the stock price and strike price.

We implement this strategy based on the following reasons. First, we consider complex trades in which all individual legs are open positions only and exclude rolling-positions trades in which some or all the individual legs are closing positions. While the data are at the individual trade level, we are not able to observe liquidation trades from the same open positions as investors could close one leg at a time. Second, assuming holding horizons of up to three days is consistent with recent evidence on single-leg options (Bryzgalova et al. (2022); Cboe (2022)), which shows that retail investors trade extensively on short-dated options, especially those with less than seven days-to-maturity. Third, we calculate the payoff for each leg of the complex options based on the closing price of the option. If the option expires before holding horizons, we assume that it will be exercised if it is in-the-money. Specifically, we calculate the return of a complex options trade as

$$\text{Return}_t = (\text{Cash flow}_t - \text{Cash flow}_0)/\text{Initial Required Capital}_0 \tag{2}$$

Where *Cash Flow*$_t$ is the payoff of the complex options based on the closing option prices of day t, and *Cash Flow*$_0$ is the net cash outlay or net premium received from the transaction price. The denominator *Initial Required Capital*$_0$ is the initial margin required that is specific to each complex option trade, outlined by the CFTC margin requirement.[11] Intuitively, return on capital can be viewed as the internal rate of return (IRR) for such trade assuming that investors liquidate the positions in one-, two-, three-days.

For instance, the cash flow of a long straddle for a one-day holding horizon is calculated as the payoff where both call and put are sold at the closing price. The initial capital requirement for such trade is the initial premium paid for both call and put. By contrast,

[11] We winsorize the return at the 0.5th and 99.5th percentiles per strategy, as in Bryzgalova et al. (2022). Results are not sensitive to the winsorization.

the initial capital requirement for a short straddle would be the greater of the margin requirement of call or margin requirement of put, where the margin requirement for the single-leg option is the greatest of the following calculations: (a) 20% of the underlying market value plus 100% of the option premium minus the out-of-money value if any; (b) 10% of the strike price plus 100% of the option premium. See the appendix for all initial margin requirements of complex options. We use the minimum capital requirement specified in Reg.T. Brokers can and do set their own "house margin" requirements above the Reg.T or statutory minimum. The initial required capital difference between the long and short positions highlights the difference in whether the position is established as a debit or credit to retail investors.

We begin by exploring whether zero-commission impacts the performance of complex options trades by retail investors. We estimate the following specifications:

$$\text{Return}_{i,t} = \alpha + \beta_1 \, \text{Post}_{i,t} \times \text{Debit}_{i,t} + \beta_2 \, \text{Debit}_{i,t} + \gamma_t + \delta_s + \varepsilon_{i,t} \tag{3}$$

Where $Return_{i,t}$ is the t-period holding return for a complex options trade i, and *POST* is a dummy variable that equals one if the observation is after the zero commission and zero otherwise. *Debit*$_{i,t}$ is a dummy variable that equals one if complex option trade i is a debit trade (i.e., a retail investor pays a premium rather than receive an upfront premium credit). In addition to the trade date fixed effect, we add the stock times strategy fixed effect to control for any unobserved characteristics within the same stock that deploys the same complex strategy. Standard errors are clustered at both firm and date levels.

[INSERT TABLE 3]

Table 3 reports the results. The first three columns report the coefficients where the holding period for return calculation is one-day, two-day, and three-day. The two main observations come out of the analysis are as follows. First, coefficients of Debit are all significant with negative signs, indicating that debit trades, on average, lose money. The results are also economically significant. Take Column 1, for example. Unconditionally, debit complex options have a return of -6.08% for a one-day holding period. Such loss increases to -9.33% and -11.09% for the two-day and three-day holding period. Second, the interaction terms are also statistically significantly negative and economically large. Compared to debit complex trade that occurred before the zero-commission period, the debit complex trade lose additional 0.63% and 1.74% for one-day and three-day horizons, respectively.

We conduct additional tests by adding $Retail_{i,t}$ dummy variable into the specifications and report the results in Columns (4)-(6). *Retail* is a dummy variable that is equal to one if stock i on date t is the top quintile of aggregate retail trading volumes based on the algorithm following Boehmer et al. (2021). The coefficients on the time-varying *Retail* are also negative, suggesting that complex option trades on stocks that are favored by retail investors lose an additional -1.22% to -1.88% returns during the first three days. Together, these results indicate that retail investors are, on average, losing money on complex options, especially among debit trades, and they are losing more money after zero-commissions.

In Appendix A3, we conduct the same analysis win which we take into account the transaction costs associated with exiting the trade, that is, instead of using the average of the bid-ask closing option price to calculate return in Equation 2, we use the bid (ask) if the exiting trade for one leg is sell (buy).[12] The results show that the debit complex options have more negative returns of -12.64%, -14.91%, and -16.36% for one-, two-, and three-days returns, respectively.

[12]We only consider the exiting transaction costs as the bid-ask costs are already embedded into the transaction price when the trade is first placed, possibly through option auctions.

3.3. Determinants of complex options trading

The previous section shows that retail investors trade more complex options after zero-commission and lose money on average in those trades. In this section, we examine the determinants of complex option trading favored by retail investors. Our empirical analysis focuses on stock-strategy level regressions, where the dependent variable is either the natural logarithm of trade or the natural logarithm of volumes. The set of independent variables includes stock realized volatility, Amihud liquidity measure, lagged market equity, turnover, past stock returns, and a dummy variable for earnings announcement date. We also include stock and date fixed effects in all the regressions. Standard errors are double clustered at the stock and date levels. To ease the interpretation, we standardize both dependent variables and continuous independent variables except return measures by subtracting the sample mean and dividing the sample standard deviation for the full sample.

[INSERT TABLE 4]

Table 4 reports the regression coefficients. Columns (1) and (4) show that retail investors favor highly volatile, large-cap stocks, and stocks that are liquid and have higher turnover. Barber et al. (2022) show that retail investors engage in more attention-induced trading, i.e., trade on stocks with absolute extreme price movement; we include two return measures to capture both positive and negative returns: *Pos Return*$_{t\text{-}5,5}$ is defined as $Max(0, Return_{\text{t-5,5}})$ while *Neg Return*$_{t\text{-}5,5}$ is defined as $Min(0, Return_{\text{t-5,5}})$ where $\text{Return}_{\text{t-5,5}}$ is the past one-week return. The coefficients on both variables show the expected signs and are statistically significant. Retail investors trade more complex options on stocks with higher positive returns and more negative returns, consistent with the attention-induced equity trading behavior observed in Barber et al. (2022). In Columns (2) and (5), we investigate complex option trade activity and earnings announcement by including the earnings announcement date dummy variable as an additional explanatory variable. The slope coefficient is 0.363 (0.231) with a t-statistic of 25.66 (25.42) for trades (volumes) as the dependent variable. This significantly positive estimate indicates that retail investors trade higher volumes of complex options on earnings announcement dates.

One unique feature of trading complex options is the special treatment of margin requirements for different complex options. Reg.T specifies the margin requirement not only for single-leg option but also for multi-leg options. For instance, the debit call spread option, which is a combination of a long call and a short call with different strike prices but the same maturity, requires no additional margin except the difference between the strike prices. We include in the regression a dummy variable *Special Margin* that equals 1 if the strategy received special margin treatment and 0 otherwise. The coefficients are statistically significant, indicating that retail investors favor complex options that have lower margin requirements or equivalently embedded leverage. Finally, for a subset of the sample where we also have the data of the Robinhood ownership from Robintrack, we control for retail trading proxied by the Robinhood ownership breadth, which is the logarithm of the number of Robinhood users holding the stock i at the end of date t. The coefficients on the *RH Users* show positive significance. Furthermore, adding a retail trading proxy improves the adjusted r-squared from 16.7% to 19.1%, suggesting that retail equity trading and retail options trading are highly correlated.

Overall, this section characterizes the complex option trading activity favored by retail investors and we find that they like trading high-volatility stocks, large-cap stocks, and stocks that are liquid and have higher turnover. They also trade complex orders on earnings announcement dates and favor trade with special low-margin requirements.

3.4. Reaching for complexity and the returns

Complex options are constructed in a similar to retail structured products where the payoff is complex and nonlinear. Recent literature on structural products shows that complex retail structured products are designed and issued to cater to yield-seeking investors and they are complex, expensive, and money-losing (Célérier and Vallée, 2017; Henderson and Pearson, 2011; Vokata, 2021). On the other hand, Calvet et al. (2022) show that securities with non-linear payoff designs can have a positive effect of fostering household risk-taking and mitigating behavioral biases to increase mean household portfolio returns. In this section, we investigate from the demand side whether retail investors benefit from or lose money from more complex trades.

Investors use options to trade not only on directional information (Stephan and Whaley (1990); Amin and Lee (1997); Easley et al. (1998), Chan et al. (2002), Chakravarty et al. (2004), Cao et al. (2005), and Pan and Poteshman (2006)) but also on volatility information (Ni et al. (2008)). Given the same trading objective (either volatility or directional), the complexity arises from the fact that retail investors can synthesize different payoff structures through a combination of multiple legs of options.

Considering the volatility betting strategy, for example, a straddle can be viewed as the simplest complex option strategy, as it is two-leg and both call and put legs have the same expiration date and strike prices. For the same volatility exposure, the complexity increases for strategies such as strangle and iron condor as the parameters for retail investors to choose increase. From a margin requirement perspective, these three strategies receive special margin treatment and require low capital compared to complex options that combine calls or puts with different strike prices and maturities.

To make a fair comparison across strategies with similar characteristics and margin requirements, we split our sample into two by two groups based on the dimensions of (1) whether the trade is directional betting or volatility betting, and (2) whether special margin requirements are received. We examine the performance of the complex options using the following specification:

$$\text{Return}_{i,t} = \alpha + \beta_1 \text{Complex}_{i,t} + \beta_2 \text{Post} \times \text{Complex}_{i,t} + \beta_2 \text{Debit}_{i,t} + \delta_{t \times s} + \varepsilon_{i,t} \quad (4)$$

Where $Return_{i,t}$ is the t-period holding return for a complex option trade i, and *POST* is a dummy variable that equals one if the observation is after the zero commission and zero otherwise. *Complex*$_{i,t}$ is a dummy variable equals one if the strategy is relatively more complex within the same group (see appendix for a detailed classification of what strategies fit into each group and what strategies are considered as more complex options). Because we are comparing the performance of different complex strategies, we add stock times date fixed effect to control for any unobserved characteristics within the same stock-date cluster. Standard errors are clustered at both firm and date levels.

[INSERT TABLE 5]

Table 5 reports the regression results where the top panel focuses on trades with normal margins while the bottom panel focuses on trades with special margin requirements. The results across all specifications show that more complex strategies yield lower returns. In column (1) in the top panel, among volatility trading strategies, more complex strategies have on average a -1.64% lower one-day return with a t-statistics of 4.01. Such returns decrease to -2.20% and -2.69% for the two-days and three-days holding horizons, respectively. Furthermore, during the commission-free period, the returns for more complex options are significantly more negative; the one-day holding return is -5.24% (-3.61%-1.64%) and it decreased to -7.03% for the three-day horizon. The patterns are generally similar for directional trading with more complex options trades having lower returns and even more negative returns for post zero-commission period. Panel B compares trades with special margin requirements. The coefficient loadings on $Complex_{i,t}$ is unconditionally more negative, consistent with the hypothesis that retail investors are losing more money among those complex trades. The interaction term is also economically negative, although it is statistically insignificant. In sum, combining the evidence that retail investors synthesize and trade more complex options and the the return evidence suggests that retail investors lose more money on those exotic options.

3.5. Complex option trading and earnings announcement

In this section, we investigate the retail investors' complex option trading activity relative to firms' quarterly earnings announcements. Earnings announcements are among the most important and salient corporate events in which a firm's fundamental information is revealed to the market. Investors respond actively to this information by comparing the announced fundamentals to their ex-ante expectations. For instance, Jegadeesh and Titman (1993) estimate that the three-day returns around earnings announcement represent approximately 25% of momentum profit. Another stylized fact is that uncertainty builds up before an information event and plummets afterward (Patell and Wolfson, 1979, 1981; Dubinsky et al., 2019).

While a large body of literature examines trading activity around earnings announcements, the focus is mainly on equity and single-leg options. We start our examination by providing descriptive analysis of complex options trading activity around earnings announcements. Specifically, we take the following form to quantify the percentage of volumes that occur on each trading day relative to the earnings announcements, controlling for firm and earnings calendar date fixed effect. The fixed effects allow for heterogeneous trends for different stocks and capture unobserved variation across stocks that make same-day earnings announcements.

$$Pct_{i,s,t} = \alpha_i + \sum_{\theta=-20}^{20} \beta_\theta \mathbf{1}_{i,t\in\theta} + \gamma_i + \delta_d + \varepsilon_{i,t} \tag{5}$$

where *i* denotes the stocks, *t* the date, *s* the complex option strategy, θ the trading date since the earnings announcement, and $\mathbf{1}_{i,t\in\theta}$ is a dummy variable that takes the value of one if a given trading date occurs on the trading date θ since the earnings announcement. The outcome variables $Pct_{i,s,t}$ denotes the trading volumes as a percentage of the total volumes across all -20 to 20 days horizons for complex strategy *s* for stock *i* on day *t*.

[INSERT FIGURE 3]

Panels A and B of Figure 3 plot the results from an event study around the time of earnings announcements for directional and volatility trades, respectively. Consistent with our results in Table 4, the magnitude of trading volumes on the earnings announcement date is substantial, with approximately 5% of directional complex option trading volumes occurring on the announcement date. Furthermore, the next most elevated trading occurs on t-1 and t+1, whereas all trades on the other trading days are almost zero. The patterns are similar for volatility complex options trades; approximately 13% of volatility complex options trading volumes occur on the announcement date and 9% and 5% of trading volumes occur on t-1 and t+1, respectively. Greater intensified option trades for volatility-betting around earnings announcements highlight an important feature of earnings announcements: retail investors trade not only the directional but also the elevated uncertainty of earnings announcements directly through complex options strategies.

We next investigate the performance of complex trades around earnings announcements by running the same specification as in Equation (4) and focusing on those trades that occurred between earnings announcement date t and t-3. Table 6 reports the results of the subsample analysis.

[INSERT TABLE 6]

Consistent with the findings in Table 3, retail investors generally lose money during the post-zero-commission period and among the complex options purchased with debit. In addition, the economic magnitude is considerably larger; debit complex options around earnings announcements have a return of -12.92% for a one-day holding period, and the holding return amounts up to -13.90% and -16.26% for the two-day and three-day holding periods, respectively. Compared with the coefficient estimates in Table 3, the coefficient estimates almost doubled across different holding horizons. In addition, complex trades during the post-zero commission period experience an additional -2% to -6% loss and stocks favored by retail investors yields lower returns.

Overall, the complex option trading activities around earnings announcements and the performance of these complex orders highlight that retail investors deploy complex strategies around earnings announcements, including both directional-based and volatility-based strategies. Furthermore, the trades are losing money on average, and the economic magnitude of loss is larger.

3.6. Subjective Expectations of implied volatility from complex options around earnings announcements

The previous session on the trades around earnings announcements shows that, on average, retail investors lose money. In this session, we explore the source of the underperformance by examining the subjective beliefs implied by volatility-based complex options around earnings announcements. Expectations about returns and volatility have important implications for asset pricing (Greenwood and Shleifer, 2014; Lochstoer and Muir, 2022). While eliciting volatility beliefs from survey data is challenging and subject to measurement errors, the granular trade data on complex options trades allow us to directly examine the ex-ante expectations of volatility around key information events such as earnings announcements, rather than relying on the risk-neutral implied volatility from hypothetical at-the-money straddle strategies.

To ease the comparison of ex-ante expectations of volatility from retail investors and realized volatility without relying on specific option pricing models, we use the range-based volatility measure.[13] Specifically, we run a univariate regression in the following specification:

$$\textit{Realized Ranged-based Volatility}_{i,t} = \alpha + \beta \times \textit{Subjective Ranged-based Volatility}_{i,t} + \gamma_t + \delta_i + \varepsilon_{i,t} \tag{6}$$

where the dependent variable *Realized Ranged-based Volatility*$_{i,t}$ is calculated as the absolute value of the log difference between the stock price on the date of placing the complex trade and the stock price on the expiration date. The independent variable *Subjective Ranged-based Volatility*$_{i,t}$ is calculated similarly based on the two break-even points from the payoff scheme for a particular volatility-based complex strategy. This implied price movement from complex strategy is retail investor's perceived expectations of volatility.

The null hypothesis of this test is that if the expectations of volatility from these complex option trades measure true expected volatility and these measures are in the same units as expected volatility, then expectations should forecast future realized volatility with a coefficient of one.[14] We focus on the most popular complex options trades that occurred t-3 to t relative to the earnings announcement date: straddle, strangle, butterfly, and iron condor. We control for the stock fixed effect and calendar date effect and cluster the standard error at both the stock and date levels.

[13] Alizadeh et al. (2002) argue that range-based volatility proxies are efficient and robust to microstructure noise.

[14] The analysis is analog to the setting of the extrapolative behavior of investors by regressing expected return on expectations of returns (Greenwood and Shleifer (2014))

[INSERT TABLE 7]

Panel A of Table 7 presents the regression results. Column 1 reports the coefficient estimate for all trades whereas Columns 2, 3, and 4 report the coefficient estimates for the different volatility-based strategies separately. The coefficient is 0.226 with a t-statistic of 7.10. While the significance of the coefficient suggests that the expected volatility and expectation of volatility are positively and highly correlated, we reject the null hypothesis with confidence that the coefficient is equal to one. The coefficient of 0.226 suggests that the expectation of volatility from the complex options trades is significantly larger than realized volatility. In other words, based on the implied volatility estimated by the complex options trades, retail investors overestimate the magnitude of uncertainty around earnings announcements. The coefficient estimates from the individual strategies show a similar pattern. Furthermore, the magnitude of the coefficient decreased from 0.553 for the two-leg straddle/strangle options to 0.202 for butterfly options and to 0.204 for the iron condor options.

Panel B of Table 7 reports the subsample analysis results where we divide the sample further into whether the trade is debit or credit, that is, whether the strategy is long or short volatility. Columns 1 and 4 report the estimates for straddle/strangle options, Columns 2 and 5 report the estimates for butterfly options, and Columns 3 and 6 report the estimates for iron condor options. In both scenarios, the patterns are similar: retail investors overestimate the magnitude of uncertainty around earnings announcements. However, the coefficient estimates are relatively larger for the debit position than for the credit position, thus implying that the range-based estimates are smaller. This is consistent with the fact that debit positions are longing volatility and retail investors profit only if the price moves beyond a certain range. Overall, the analysis in this section provides novel evidence regarding subjective expectations of volatility through volatility-based complex trades. We show that the implied volatility from these complex trades is greater than the expected volatility, regardless of the strategies they use, suggesting that retail investors overestimate the uncertainty around earnings announcements.

4. Conclusion

In this study, we examine retail trading in complex options, which provides a unique setting for understanding the effects of financial product complexity and risk shrouding on retail traders. Zero-commission options trading was first introduced by Robinhood for single-leg options in January 2017 and other brokers. Schwab, E-Trade, and TD Ameritrade switched to a zero commission retail trade model in 2019. Using transactions prices on complex trades as a single unit, we document that retail traders lose money over one-, two-, and three-day holding periods. We also show that complex option trading is elevated around earnings announcements, with corresponding trading volume from t-2 to t+1 accounting for more than 12% to 28% of total complex options trading volume. Importantly, retail trader losses are three times larger on these trades. Complex strategies are also used to bet on extreme volatility: straddles and strangles are popular volatility strategies. We examine the expectation of volatility and the realized volatility from volatility-based complex trades, and we find that retail investors systematically overestimate the realized volatility based on complex option price spreads. The demand for complex options by retail investors follows their revealed attraction to low-price, high volatility, high leverage, and lottery-like assets (low probability of large positive return, and a high probability of negative returns). The consistent average negative returns on their complex trading bets suggest that retail investors are on average uninformed and are attracted to low priced, high leverage strategies.

Our study highlights the impact of financial technology innovation, financial product complexity, and risk shrouding on retail traders' choices and performance outcomes. While our study focus on the welfare aspect of retail investors, other aspects of the complex option tradings, such as the variation in information content of complex trades and execution quality of complex securities are fruitful areas yet to be fully explored. Our findings also have important policy implications regarding the design, disclosure, trading, and regulation of complex financial products, including the embedded leverage design from complex options due to different margin requirements.

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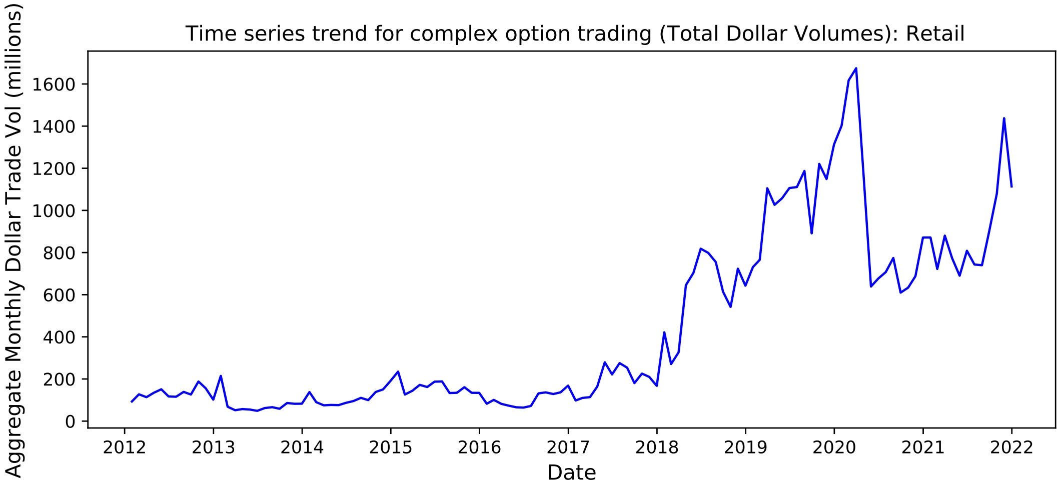
Figure 1. The Trend of Complex Option Trading

This figure plots the monthly aggregate total dollar volumes (top panel) and the monthly aggregate total trades (bottom panel) for retail complex options strategies during our sample period.

Panel A: Dollar Volumes:



Panel B: Number of Trades

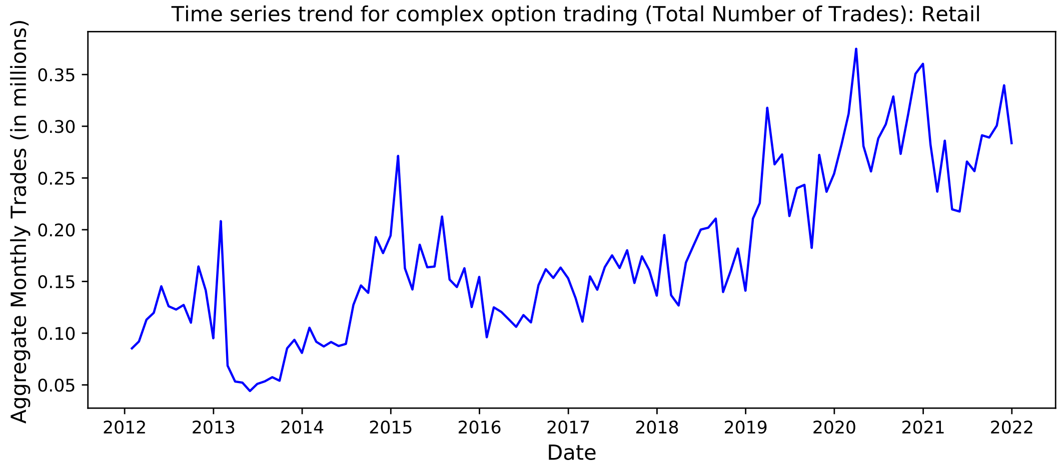


Figure 2. Popularity of Complex Options

This figure shows the top traded complex strategies ranked by the density during our sample period. The definition of strategies is in Appendix Table A2

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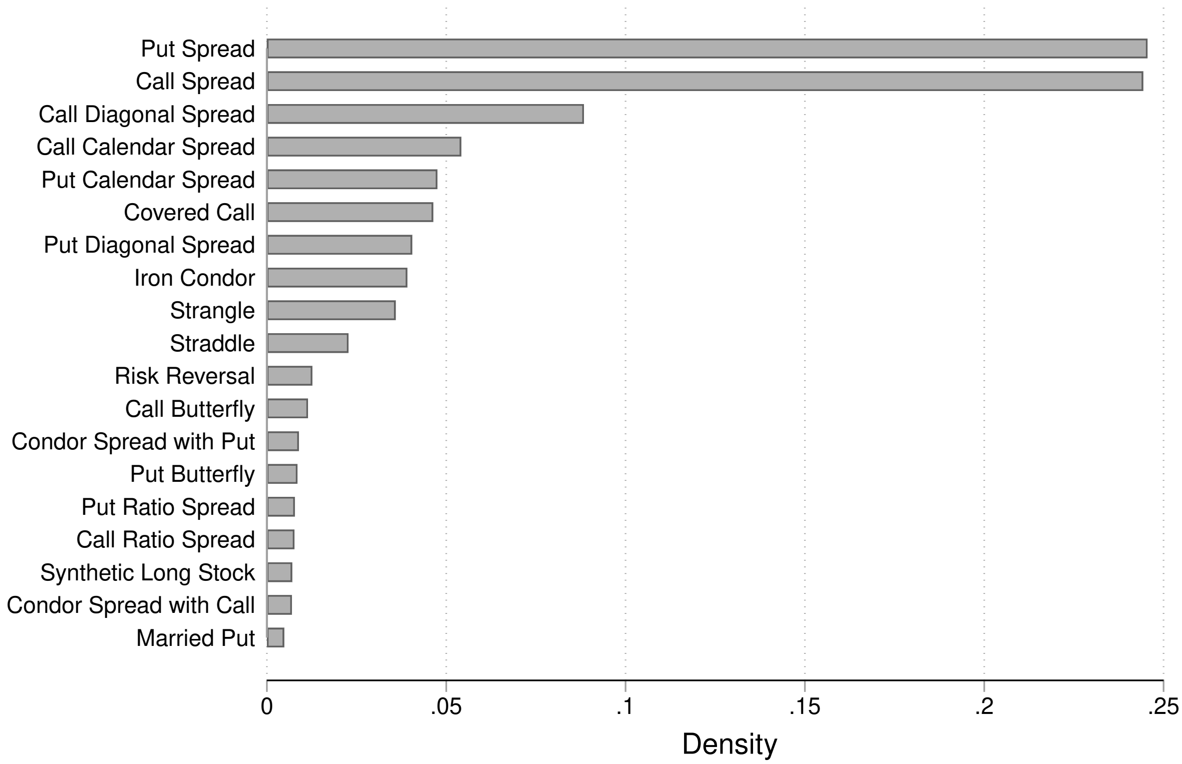


Figure 3. Trading Volumes of Directional Complex Strategies around Earning Announcement

This figure shows OLS estimates for a set of day time fixed effects along with 95 percent confidence intervals that allows us to assess the trading volumes during the 20 days preceding the earnings announcement as well as during each of the 20 days following earnings announcement. The dependent variables are the daily trading volumes. We control for the stock and calendar time fixed effects.

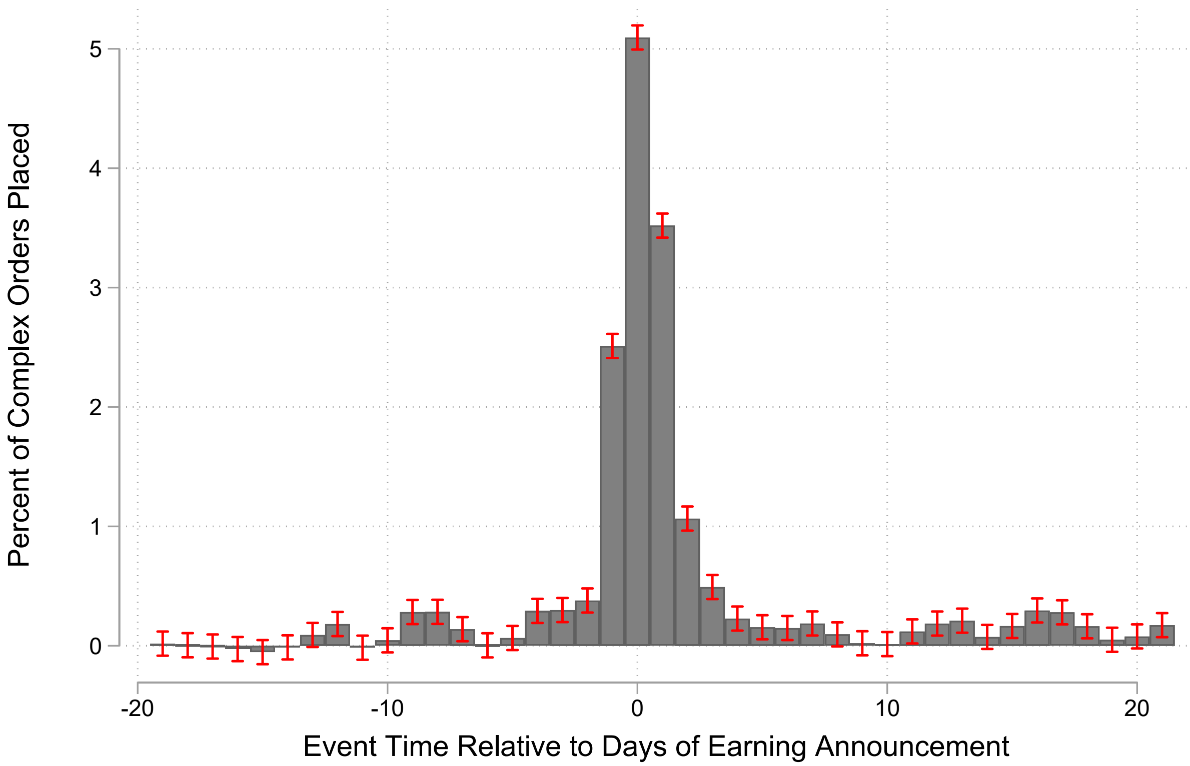


Figure 4. Trading Volumes of Volatility Complex Strategies around Earnings Announcement

This figure shows OLS estimates for a set of day time fixed effects along with 95 percent confidence intervals that allows us to assess the trading volumes during the 20 days preceding the earnings announcement as well as during each of the 20 days following earnings announcement. The dependent variables are the daily trading volumes. We control for the stock and calendar time fixed effects.

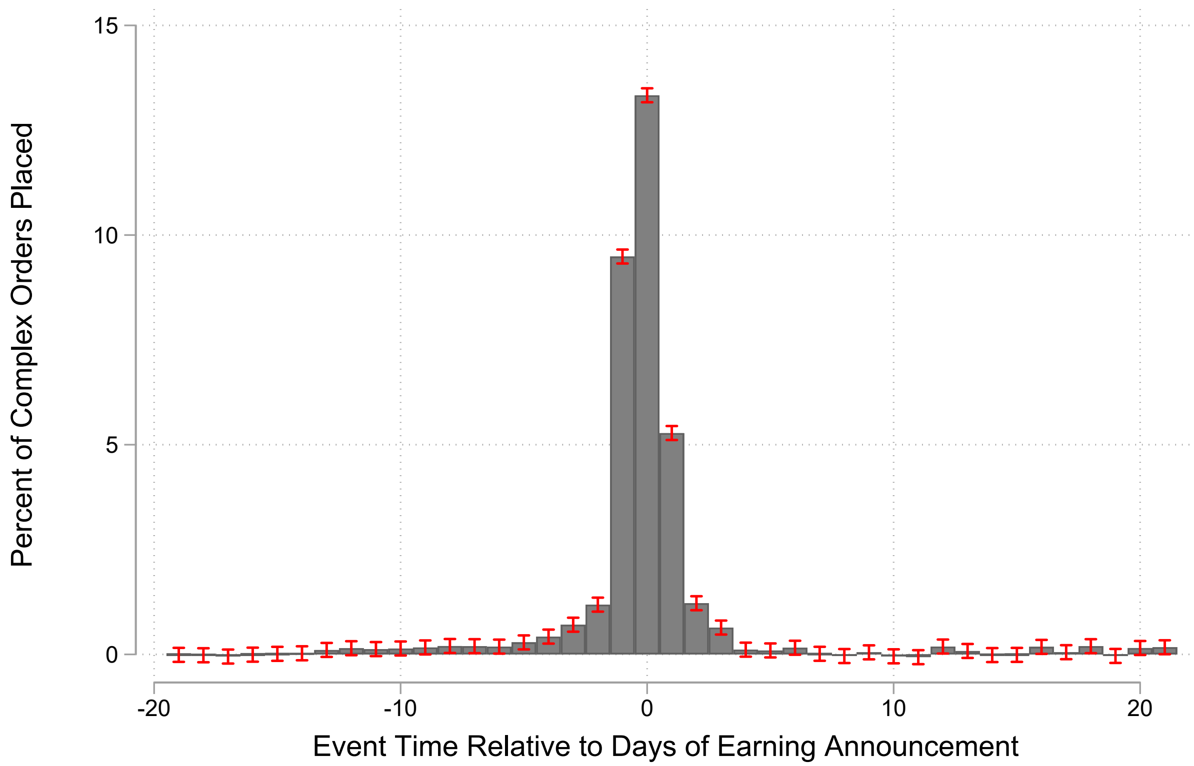


Table 1. Summary Statistics

The table reports the summary statistics for retail complex option trades. Panel A presents trade level summary statistics for all complex trades. Panel B, C, and D presents the summary statistics for two-leg options, three-leg options, and options with more than four legs, respectively. Contract volume is the number of contract per trade. Dollar Premium is the transaction price in dollar. *Debit* is a dummy variable equals one if investor pays premium rather than receive upfront premium credit. Days to Maturity is the shortest days-to-maturity among all legs. Returns are calculated in percent from Equation 2. The sample period is from January 2012 to December 2021.

Panel A: All

	Mean	Std. Dev.	P25	Median	P75	Skewness
Contract Volume	8.67	60.70	1.00	2.00	6.00	384.94
Dollar Premium	5136.86	66379.34	110.00	324.00	1250.00	173.60
Debit	0.51	0.50	0.00	1.00	1.00	-0.02
Days to Maturity	55.83	106.25	7.00	24.00	50.00	4.15
Return_{1d}	-1.81	37.31	-6.60	0.00	4.87	20.84
Return_{2d}	-1.96	47.12	-8.81	0.19	6.77	19.09
Return_{3d}	-2.06	57.85	-10.90	0.37	8.29	31.53

Panel B: Two legs

	Mean	Std. Dev.	P25	Median	P75	Skewness
Contract Volume	8.97	63.63	1.00	2.00	6.00	376.36
Dollar Premium	5195.27	66978.17	110.00	340.00	1360.00	182.66
Debit	0.52	0.50	0.00	1.00	1.00	-0.06
Days to Maturity	57.52	108.87	8.00	24.00	51.00	4.08
Return_{1d}	-1.72	33.93	-6.56	0.00	4.94	31.94
Return_{2d}	-1.82	42.92	-8.70	0.22	6.85	29.10
Return_{3d}	-1.86	54.03	-10.71	0.41	8.38	43.86

(Continued.)

Panel C: Three legs

	Mean	Std. Dev.	P25	median	P75	Skewness
Contract Volume	7.33	34.09	1.00	1.00	5.00	37.42
Dollar Premium	6831.99	90689.55	69.00	200.00	650.00	54.72
Debit	0.72	0.45	0.00	1.00	1.00	-1.00
Days to Maturity	52.50	100.20	7.00	21.00	46.00	4.02
$Return_{1d}$	-4.04	46.44	-12.93	-0.52	4.50	1.77
$Return_{2d}$	-5.67	55.97	-19.75	-0.67	5.83	2.07
$Return_{3d}$	-6.84	63.89	-26.50	-1.04	6.46	2.58

Panel D: Four or more legs

	Mean	Std. Dev.	P25	Median	P75	Skewness
Contract Volume	5.45	23.77	1.00	1.00	4.00	57.32
Dollar Premium	2971.24	16034.83	120.00	270.00	715.00	19.47
Debit	0.18	0.38	0.00	0.00	0.00	1.67
Days to Maturity	34.72	62.23	4.00	22.00	43.00	5.29
$Return_{1d}$	-1.58	68.91	-4.47	0.00	4.07	-2.80
$Return_{2d}$	-1.42	89.56	-5.50	0.40	6.00	-2.63
$Return_{3d}$	-1.59	101.45	-6.90	0.70	7.60	-3.60

Table 2. Zero-Commission Trading and Complex Option Trades

The table examines the relationship between complex option trades by retail investors and zero-commission in complex option trading, especially among stocks favored by retail investors. The dependent variables are natural log of trades (Columns 1,3,5,7) and natural log of volumes (Columns 2,4,6,8). The independent variable *Post* $\times$ *Retail* is the interaction term of a dummy variable *Post* which is equal to 1 during the post zero-commission period (June 2018-Dec 2021) and a dummy variable *Retail*, which is equal to 1 if the stocks are in the top quintile of Robinhood ownership based on the number of stock owners at the time of June 2018. *Two-legs*, *Three-legs*, and *Four or more legs* represents the number of constituents of single-leg options are in each complex trade. We include both Firm fixed effect and Month fixed effect. Standard errors are clustered at firm and month level and reported in the parenthesis. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

	All		Two legs		Three legs		Four or more legs	
	Trades	Volumes	Trades	Volumes	Trades	Volumes	Trades	Volumes
Post $\times$ Retail	0.562***	0.361***	0.566***	0.367***	0.790***	0.305***	0.579***	0.396***
	(7.74)	(7.94)	(7.82)	(8.18)	(7.99)	(5.23)	(6.65)	(6.87)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	268,555	268,555	266,062	266,062	65,319	65,319	65,186	65,186
Adj.R-sq	0.540	0.645	0.535	0.641	0.360	0.436	0.414	0.532

Table 3. The Performance of Complex Option Trades

The tables examine the performance of complex option trades around zero-commission periods. The dummy variable *Post* equals to 1 during the zero-commission period (June 2018 to December 2021). The dummy variable *Debit* equals 1 if the investor pays a premium and 0 if the investor receives upfront credit. The *Retail* dummy variable equals to 1 if the Boehmer et al. (2021) based retail volumes is top quintile cross-sectionally. The dependent variables are return on capital in percentage for the one-day horizon, two-day horizon, and three-day horizon. If option from any legs has maturity less than the holding horizons, the return on capital assuming the options held until maturity is used. We include stock times strategy fixed effect and date fixed effect. Standard errors are clustered at firm and date levels and reported in the parenthesis. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Debit	-0.625* (-1.70)	-1.324** (-2.23)	-1.737*** (-2.72)	-0.634* (-1.72)	-1.336** (-2.25)	-1.751*** (-2.73)
Debit	-6.081*** (-14.93)	-9.330*** (-14.43)	-11.09*** (-14.56)	-6.077*** (-14.97)	-9.322*** (-14.45)	-11.08*** (-14.57)
Retail				-1.223*** (-8.90)	-1.529*** (-7.73)	-1.883*** (-7.96)
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Stock × Strategy FE	Yes	Yes	Yes	Yes	Yes	Yes
N	7,789,648	7,784,269	7,767,754	7,789,648	7,784,269	7,767,754
Adj.R-sq	0.060	0.069	0.099	0.060	0.069	0.100

Table 4. The Determinants of Complex Options Trades

The table reports the determinants of complex options trades. Columns 1, 2, and 3 are natural logarithm of trades and Columns 4, 5, and 6 are natural logarithm of volumes. The indepedent variables include Volatility, liquidity measure, lagged market equity, turnover, past stock return, EA dummy, special margin. The observations is at stock-strategy-date level and the sample period is from 2012 to 2021. Both dependent variables and independent variables (except returns) are normalized for the ease of interpretation. Standard errors are double clustered at the stock and day level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

	Trades			Volumes		
	(1)	(2)	(3)	(4)	(5)	(6)
Volatility	0.0222***	0.0252***	0.0342***	0.0183***	0.0201***	0.0197***
	(3.53)	(4.17)	(3.61)	(4.05)	(4.61)	(2.92)
Amihud	-0.0310**	-0.0324**	-0.0261*	-0.0119*	-0.0126*	-0.017
	(-2.00)	(-2.01)	(-1.79)	(-1.91)	(-1.95)	(-1.46)
Market Cap	0.0717***	0.0733***	0.0572***	0.0379***	0.0388***	0.0181*
	(3.28)	(3.33)	(3.81)	(5.90)	(6.03)	(1.69)
Turnover	0.654***	0.661***	0.496***	0.477***	0.481***	0.287***
	(4.12)	(4.12)	(3.69)	(3.93)	(3.93)	(2.99)
Pos Return$_{t-5,5}$	0.464***	0.456***	0.345**	0.324***	0.319***	0.232**
	(3.11)	(3.14)	(2.27)	(2.86)	(2.88)	(2.09)
Neg Return$_{t-5,5}$	-0.699***	-0.693***	-0.541***	-0.548***	-0.542***	-0.421***
	(-8.82)	(-8.93)	(-5.71)	(-9.11)	(-9.21)	(-5.86)
EA Dummy		0.363***	0.367***		0.231***	0.241***
		(25.66)	(25.10)		(25.42)	(23.76)
Special Margin		0.0623***	0.160***		0.0288***	0.0777***
		(5.70)	(8.90)		(3.25)	(5.58)
RH Users			0.0747***			0.0587***
			(5.60)			(4.42)
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
N	3,437,670	3,437,670	1,041,838	3,437,670	3,437,670	1,041,838
Adj.R-sq	0.161	0.167	0.191	0.099	0.101	0.122

Table 5. The Performance of Complex Options and Complexity

The table studies the relationship between complexity and the performance of complex options. Panel A examines the trades with standard normal margin requirements, and Panel B examines the trades with special margin requirements. The dependent variables are returns on capital for one-day horizon (Columns 1,4), two-day horizon (Columns 2,5), and three-day horizon (Columns 3,6). If option from any legs has maturity less than the holding horizons, the return on capital assuming the options held until maturity is used. The dummy variable *Complex* equals 1 if a complex option trade has a more complex payoff structure than the most simple strategies within the same category. We include stock times date fixed effect and standard errors are double clustered at the stock and day level. *t*-statistics are presented in parentheses. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

Panel A: Trades with Normal Margin

	Volatility Trading			Directional Trading		
	(1)	(2)	(3)	(4)	(5)	(6)
Complex	-1.638***	-2.195***	-2.692***	-0.594**	-0.758**	-1.174***
	(-4.01)	(-4.68)	(-5.47)	(-2.16)	(-2.32)	(-2.72)
Post $\times$ Complex	-3.605***	-4.091***	-4.346***	-0.296	-2.139***	-3.899***
	(-4.64)	(-5.02)	(-5.41)	(-0.77)	(-3.05)	(-3.73)
Stock $\times$ Date FE	Yes	Yes	Yes	Yes	Yes	Yes
N	674,012	664,005	654,413	800,154	796,321	792,435
Adj.R-sq	0.402	0.395	0.387	0.416	0.340	0.264

Panel B: Trades with Special Margin

	Volatility Trading			Directional Trading		
	(1)	(2)	(3)	(4)	(5)	(6)
Complex	-2.680***	-4.210***	-5.434***	-2.416***	-2.572***	-2.631***
	(-5.80)	(-7.32)	(-9.62)	(-14.17)	(-11.08)	(-9.38)
Post $\times$ Complex	-0.661	-0.980	-1.145	-0.159	-0.264	-0.491
	(-1.07)	(-1.44)	(-1.49)	(-0.68)	(-0.84)	(-1.27)
Stock $\times$ Date FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1,626,341	1,606,998	1,600,518	4,990,563	4,982,948	4,976,449
Adj.R-sq	0.175	0.165	0.175	0.185	0.199	0.207

Table 6. The Performance of Complex Option Trades around Earnings Announcements

The tables examines the performance of complex option trades around earnings announcements. The dummy variable *Post* equals to 1 during zero-commission period (June 2018 to December 2021). The dummy variable *Debit* equals to 1 if the investor pays premium and 0 if the investor receives upfront credit. The *Retail* dummy variable equals to 1 if the Boehmer et al.(2021) based retail volumes is top quintile cross-sectionally. The dependent variables are return on capital in percentage for one-day horizon, two-day horizon, and three-day horizon. If option from any legs has maturity less than the holding horizons, the return on capital assuming the options held until maturity is used. We include stock times strategy fixed effect and date fixed effect. Standard errors are clustered at firm and date level and reported in the parenthesis. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Debit	-2.615*	-6.006***	-6.159***	-2.645*	-6.035***	-6.194***
	(-1.72)	(-3.00)	(-2.76)	(-1.74)	(-3.01)	(-2.78)
Debit	-12.92***	-13.90***	-16.26***	-12.91***	-13.88***	-16.24***
	(-18.26)	(-11.54)	(-12.66)	(-18.45)	(-11.59)	(-12.74)
Retail				-2.116**	-2.076*	-2.425*
				(-2.43)	(-1.83)	(-1.83)
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Stock × Strategy FE	Yes	Yes	Yes	Yes	Yes	Yes
N	523,673	513,554	509,695	523,673	513,554	509,695
Adj.R-sq	0.162	0.128	0.139	0.162	0.128	0.139

Table 7. Subjective Implied Volatility and Realized Volatility

The table reports the coefficients of regressing realized range-based volatility on option-implied range-based volatility around earnings announcement. We include stock fixed effect and date fixed effect. Standard errors are clustered at firm and date level and reported in the parenthesis. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

Panel A: All

	Realized Range-based Volatility			
	(1)	(2)	(3)	(4)
	All	Straddle/ Strangle	Butterfly	Iron Condor
Subjective Range-Based Volatility	0.226***	0.553***	0.202***	0.204***
	(7.10)	(14.58)	(5.41)	(6.98)
Constant	0.0652***	0.0587***	0.0612***	0.0512***
	(20.08)	(28.00)	(19.62)	(9.49)
N	344941	188652	51576	104013
Adj.R-sq	0.388	0.382	0.407	0.595

Panel B: Conditional on whether paying premium(debit) or not (credit)

	Debit			Credit		
	(1)	(2)	(3)	(4)	(5)	(6)
Subj Range-Based Volatility	0.638***	0.299***	0.262***	0.519***	0.0904***	0.201***
	(14.13)	(13.04)	(7.92)	(13.19)	(12.72)	(6.09)
Constant	0.0416***	0.0531***	0.0503***	0.0686***	0.0714***	0.0512***
	(13.15)	(28.19)	(13.94)	(39.29)	(161.97)	(8.01)
N	80533	45699	12336	107755	4559	89497
Adj.R-sq	0.482	0.422	0.431	0.386	0.528	0.634

Appendix Tables and Figures

Appendix Table A1. Variable Definitions

This appendix describes how we construct variables used in our analysis.

Variable	**Definition**
Aggregate Retail Volume	Total retail volume, using Boehmer et al., (2020) to identify retail trades. Source: TAQ.
Book-to-Market	The ratio of book equity from the most recent fiscal year to the market equity from the most recent December. Source: Compustat and CRSP
Debit	Dummy variable equals to 1 if the complex options requires investors to pay net premium and 0 otherwise
Amihud Measure	Absolute return over the trading volumes
Retail	Dummy variable equals to 1 if the total retail volume, defined based on Boehmer et al., (2022) or Robintrack (in Table 2) is in the top quintile cross-sectionally.
Volatility from Daily Returns	Realized Volatility of stock based on past 30 trading days daily returns
EA Dummy	Dummy variable equals to 1 if a stock has earnings announcement on that day.
Realized Ranged-based Volatility	The absolute value of the log difference between the stock price at the date of placing the complex trade and the stock price at the expiration date.
Subjective Ranged-based Volatility	Range-based volatility based on the two break-even points from the following volatility-based complex trades: straddle, strangle, butterfly, and iron condor
Holding Return of a Complex Trade	The difference between $\textit{Cash Flow}_t$ and $\textit{Cash Flow}_0$ are divided by $\textit{Initial Required Capital}_0$. $\textit{Cash Flow}_t$ is the payoff of the complex options based on closing option prices of day t and $\textit{Cash Flow}_0$ is net cash outlay or net premium received from the transaction price. The denominator $\textit{Initial Required Capital}_0$ is the initial margin required that are specific to each complex option trade, outlined by CFTC margin requirement.

Appendix Table A2. Strategy Definitions

This appendix describes complex option strategies used in our analysis.

Two legs Options		
Strategy	**Definition**	**Margin Requirement**
Put Spread	Long a put and short a put with the same expiration date	For debit spread, the net premium of the two options. For credit spread, the Strike price differences minus the premium received
Call Spread	Long a call and short a call with the same expiration date	Same as Put Spread
Call Calendar Spread	Long a call and short a call with the same strike price but different expiration dates	For a short calendar spread, the cost of the long option plus the margin required on the short option. For a long calendar spread, the next cost of the spread
Put Calendar Spread	Long a call and short a call with the same strike price but different expiration dates	Same as Call Calendar Spread
Call Diagonal Spread	Long a call and short a call with the different strike price and different expiration dates	The cost of the long option plus the margin required on the short option.
Put Diagonal Spread	Long a put and short a put with the different strike price and different expiration dates	Same as Call Diagonal Spread
Covered Call	Long 100 shares of underlying equity and sell a Call	The cost of the shares minus the net premium received from the call
Married Put	Long 100 shares of underlying equity and purchase a put	The cost of the shares plus the cost of the long option
Risk Reversal	Sell an OTM put and buy an OTM call	The cost of the long option plus the margin required on the short option.
Synthetic Long Stock	Sell a put and buy a call at the same Strike Price	The cost of the long option plus the margin required on the short option.
Synthetic Long Stock	Sell a put and buy a call at the same Strike Price	The cost of the long option plus the margin required on the short option.

Table A2 continued.

Strategy	Definition	Margin Requirement
	Two legs Options	
Strategy	**Definition**	**Margin Requirement**
Straddle	Long a put and long a call with the same expiration date and same strike price	For debit spread, the net premium of the two options. For credit spread, the margin required on one of the short options minus the premium received
Strangle	Long a put and long a call with the same expiration date but different strike price	For debit spread, the net premium of the two options. For credit spread, the margin required on one of the short options minus the premium received
	Three Legs Options	
Call Butterfly	Buy one call at a lower strike price, sell two calls with a higher strike price and buy one call with an even higher strike price. All calls have the same expiration date, and the strike prices are equidistant.	The cost of the spread or the differences between the middle strike price and the lower striker price minus the cost of the spread
Put Butterfly	Buy one call at a lower strike price, sell two calls with a higher strike price and buy one call with an even higher strike price. All calls have the same expiration date, and the strike prices are equidistant.	Same as the Call Butterfly

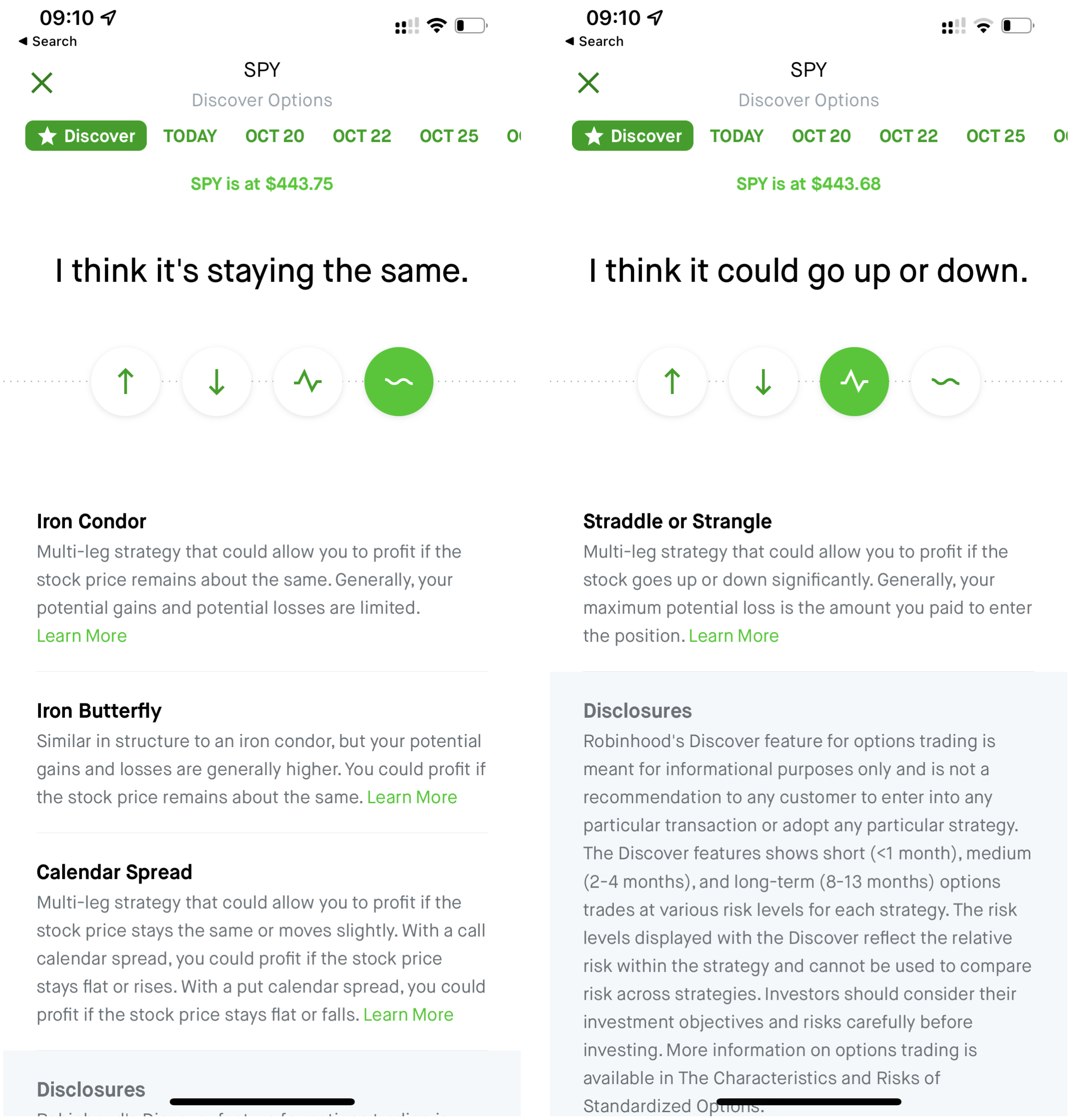
Table A2 continued.

Four Legs Options		
Strategy	**Definition**	**Margin Requirement**
Iron Condor	two puts (one long and one short) and two calls (one long and one short), and four strike prices, all with the same expiration date	For debit spread, the net premium of the two options. For credit spread, the price differences between the lowest two strike price minus the premium received
Condor Spread with Put	four puts (two long and two short), and four strike prices, all with the same expiration date	For debit spread, the net premium of the two options. For credit spread, the price differences between the lowest two strike price minus the premium received
Condor Spread with Call	four puts (two long and two short), and four strike prices, all with the same expiration date	For debit spread, the net premium of the two options. the price differences between the lowest two strike price minus the premium received

Any options involved with unhedged open short leg	
Strategy	**Margin Requirement**
Short Call/Put	The greater of the following: (1) 25% of the underlying security value minus the out-of-the-money amount (if any), plus the premium received. (2) 10% of the underlying security value plus premium received

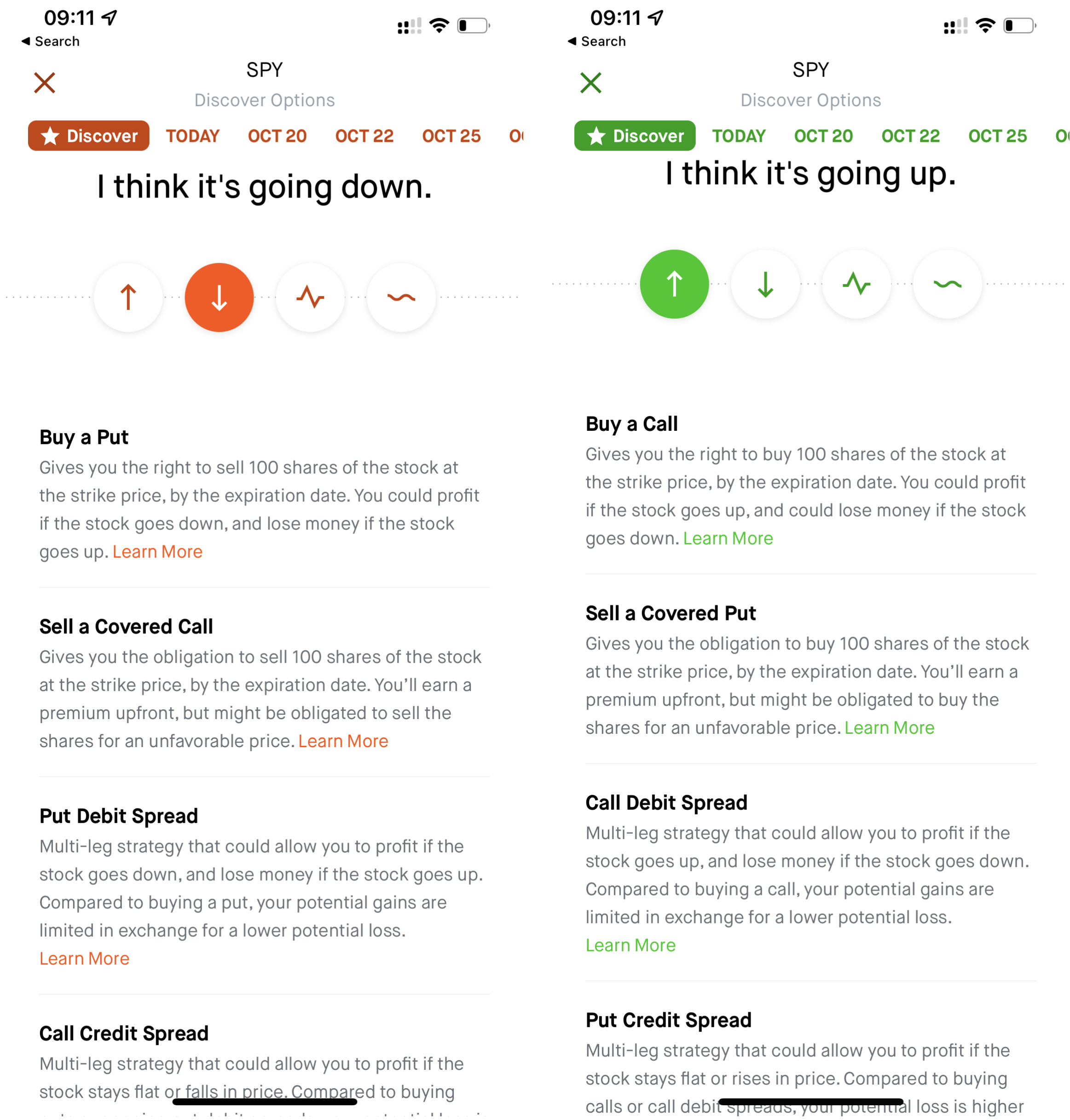
Appendix Figure A1. Trading Platform of complex orders

The screenshot of Robinhood platform for trading complex orders



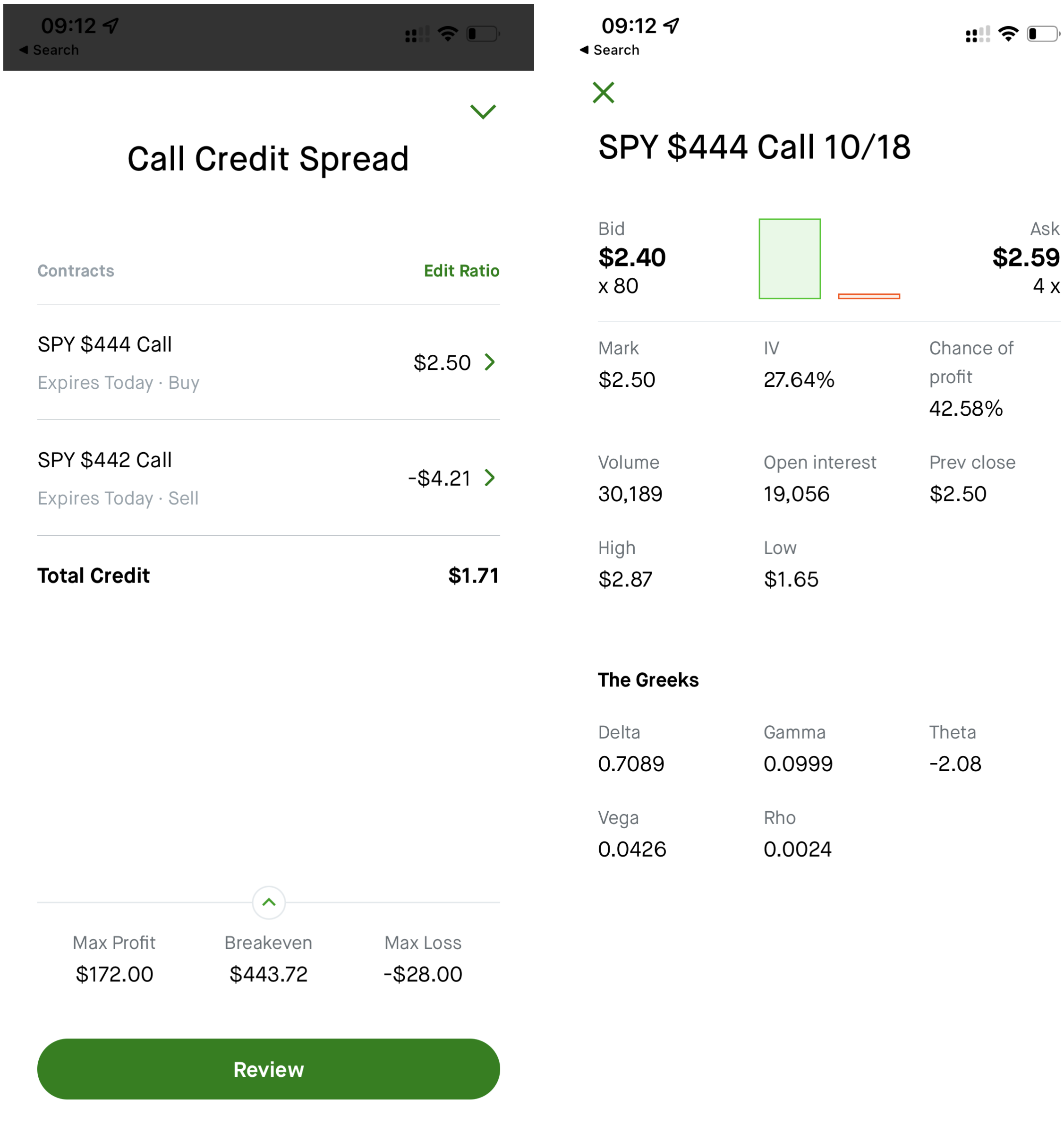
Appendix Figure A2. Trading Platform of complex orders

The screenshot of Robinhood platform for trading complex orders



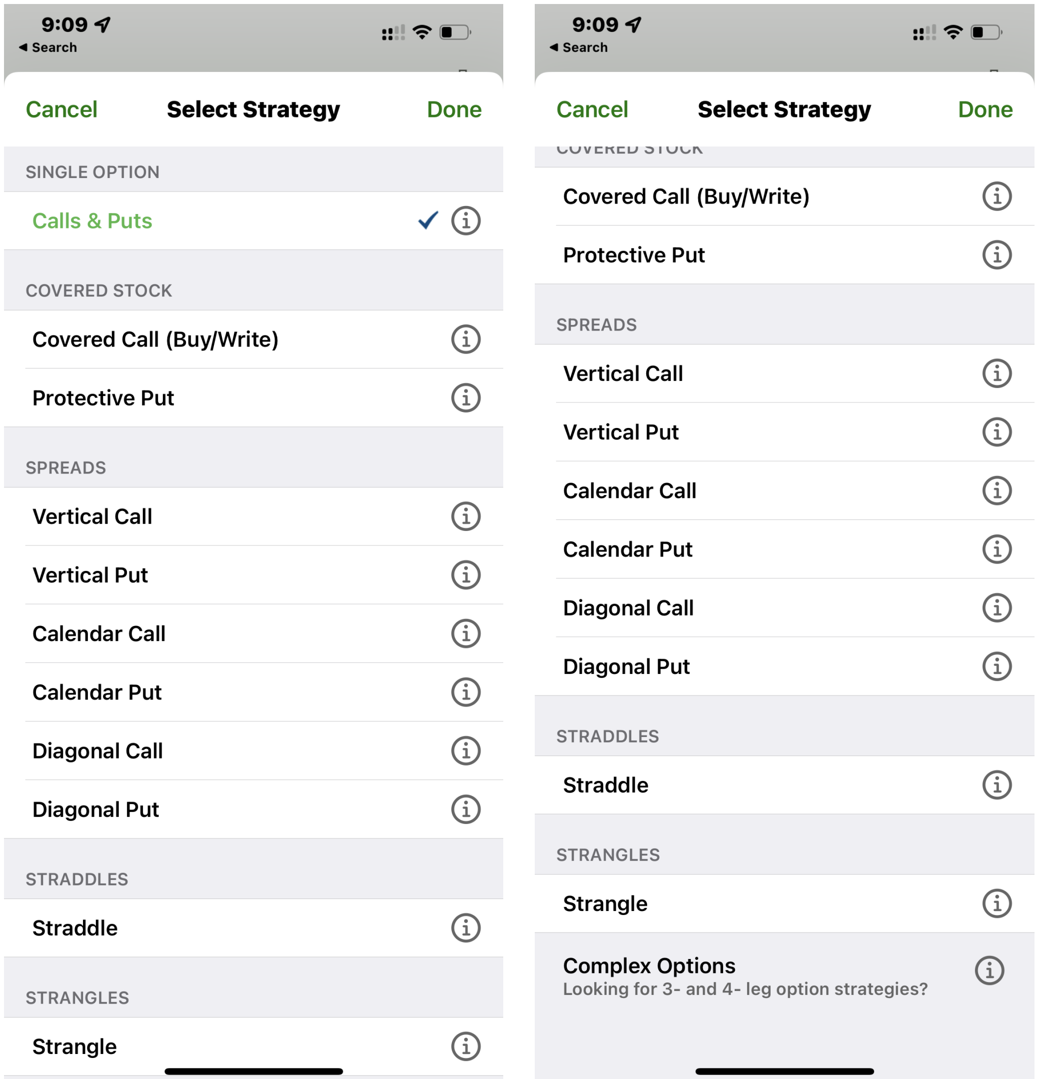
Appendix Figure A3. Trading Platform of complex orders

The screenshot of Robinhood platform for trading complex orders



Appendix Figure A4. Trading Platform of complex orders

The screenshot of TD American platform for trading complex orders



Appendix Table A3. The Performance of Complex Option Trades: Including Exiting Transaction costs

The tables examines the performance of complex option trades around zero-commission periods. The dummy variable *Post* equals to 1 during zero-commission period (June 2018 to December 2021). The dummy variable *Debit* equals 1 if the investor pays premium and 0 if the investor receives upfront credit. The *Retail* dummy variable equals to 1 if the Boehmer et al. (2021) based retail volumes is top quintile cross-sectionally. The dependent variables are return on capital in percentage for one-day horizon, two-day horizon, and three-day horizon. If option from any legs has maturity less than the holding horizons, the return on capital assuming the options held until maturity is used. We include stock times strategy fixed effect and date fixed effect. Standard errors are clustered at firm and date level and reported in the parenthesis. *, **, and *** indicate statistical significance for it at the 10%, 5%, and 1% levels, respectively.

	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$	$Return_{1d}$	$Return_{2d}$	$Return_{3d}$
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Debit	-1.899***	-2.600***	-3.013***	-1.908***	-2.609***	-3.023***
	(-3.47)	(-4.36)	(-4.63)	(-3.49)	(-4.36)	(-4.63)
Debit	-12.64***	-14.91***	-16.36***	-12.63***	-14.90***	-16.35***
	(-18.84)	(-19.74)	(-20.46)	(-18.88)	(-19.78)	(-20.51)
Retail				-1.263***	-1.232***	-1.353***
				(-6.73)	(-5.30)	(-4.82)
Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Stock × Strategy FE	Yes	Yes	Yes	Yes	Yes	Yes
N	7,715,659	7,635,543	7,565,733	7,715,659	7,635,543	7,565,733
Adj.R-sq	0.218	0.187	0.178	0.218	0.187	0.178