Retail Traders Love 0DTE Options... But Should They?*

Heiner Beckmeyer† Nicole Branger‡ Leander Gayda§

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Abstract

Our study investigates trading in options that expire on the same day – so-called "0DTE" options – through the lens of retail investors. Using the recently activated Automated Price Improvement Mechanism to identify option trades that originate from retail investors, we find a strong preference for 0DTE options. Today, more than 75% of their trades in S&P 500 options involve 0DTE contracts. Despite benefiting from lower effective spreads due to the price improvement mechanism, retail investors experience substantial losses. We explore the factors influencing how retailers are positioned in this market, and identify several drivers for their poor performance, both in the aggregate and at the level of individual trades.

Keywords: retail trading, options, preferences, payment for order flow, 0DTE

JEL classification: G4, G5, G12, D4

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†University of Münster. heiner.beckmeyer@wiwi.uni-muenster.de.

‡University of Münster. nicole.branger@wiwi.uni-muenster.de.

§University of Münster. leander.gayda@wiwi.uni-muenster.de.

1. Introduction

Retail investors love options that expire on the same day. For most of 2022 and all of 2023, these so-called "0DTE" options (short for zero days to expiration) represent more than 75% of the total volume that retail investors transact in S&P 500 index options. Their lottery-like payoffs (Bali, Cakici, and Whitelaw, 2011; Filippou, Garcia-Ares, and Zapatero, 2018) and perceived potential for generating quick profits seemingly appeal to retail investors. Today, there are numerous websites aimed at teaching retailers how to trade these options,[1] and "0DTE" is frequently discussed on several Reddit forums, such as r/wallstreetbets. User reports on r/wallstreetbets have documented both success stories and losses of tens of thousands of dollars trading 0DTE options.

The recent surge in 0DTE options trading is accommodated by a longstanding effort of the Chicago Board Options Exchange (Cboe) towards offering shorter-term options with additional expirations. In 2005, Cboe initiated a pilot program that introduced options with weekly expirations on each Friday. In 2016, Monday and Wednesday expirations were added. As of May 2022, the Cboe introduced options that expire on each weekday. While short-term options allow investors to hedge risks with greater precision, they can also be used for speculative purposes. The lower nominal prices of short-term options may have contributed to the overall increase in retail participation in S&P 500 options trading. At the same time, on July 9, 2020 the Securities Industry and Financial Markets Association ("SIFMA") issued a letter to Cboe supporting the changes in proposal SR-CBOE-2020-051 to encourage greater retail participation in S&P 500 index options. Cboe proposed to activate its Automated Price Improvement Mechanism for S&P 500 options, a move which SIFMA notes "should incentivize increased retail customer auction participation in SPX options and provide retail customers with execution and price improvement opportunities

[1] For example `https://0-dte.com` or `https://tastylive.com/`.

in SPX options".[2] Price improvements for smaller order sizes, which are naturally favored by retail traders, are thought to attract more retail flows. At the same time, Cboe notes that smaller order sizes are also favored by market makers who take the opposite side of the trades. Smaller orders are easier to hedge and thus may encourage market makers to compete to provide price improvement to retail investors.

As a consequence of these developments, this paper investigates if retail investors have benefited from trading 0DTE options. We provide a systematic assessment of retail trading in 0DTE options on the S&P 500, and study the drivers of their demand and their profitability. With this, and to the best of our knowledge, our study is the first to systematically assess the trading behavior in 0DTE options in general, and its implications for retail investors in particular.

Measuring Retail Participation in 0DTE Options. We can identify retail trades in S&P 500 options that enjoyed price improvements through the aforementioned Automated Price Improvement Mechanism. Since February of 2021, the corresponding trades receive transaction codes "SLAN", short for "Single Leg Auction Non ISO", and "MLAT" for "Multi-leg Auction". Of course, this approach identifies only a subset of retail trades in 0DTE options on the S&P 500, namely those that are internalized and consequently executed against the dealer's own inventory. However, anecdotal evidence from Interactive Brokers, as one of the major brokers catering to retail traders, gives credence to our identification approach. In a 2023 earnings call, executives were asked about the recent growth in 0DTE options trading by retail investors. Specifically referring to how they deal with this order flow, they responded with "[...] The way we participate, and our customers participate in these zero-day options – expiring options – is that we often send

[2] https://www.sifma.org/wp-content/uploads/2020/07/SIFMA-Comment-Letter-on-Cboe-SPX-AIM-.pdf

the customer orders into price improvement auctions."[3] Although dealers may decide to internalize only a fraction of the retail order flow they buy and route the remainder to Cboe as the exchange for S&P 500 options, identifying this internalized order flow allows us to study the implications of the proposals by Cboe to attract more retail demand.[4]

Several other studies on the equity options market rely on the same identification of retail trading (Bryzgalova, Pavlova, and Sikorskaya, 2023; Ernst and Spatt, 2022). We differ from these studies by a) focusing on the rapidly growing market for 0DTE options on the S&P 500, and b) by also incorporating retail trading in multi-leg strategies. Whereas the aforementioned studies focus exclusively on single-leg trades, we find that the consideration of multi-leg trades is vital for a comprehensive description of retail trading in 0DTE options. The share of identified retail trades that involve multiple options exceeds 80% at the beginning of 2021 and 30% towards the end of 2023. Complex multi-leg option strategies are typically employed to reduce the required margin by altering the risk profile of the strategy, or to place bets on the volatility of the underlying index. The trading activity in multi-leg strategies has recently received some attention among academics (Li, Musto, and Pearson, 2023, 2024). We follow Li (2020) to identify the complex options strategies pursued by retail investors. Notably, we can classify 97.99% of all multi-leg retail trades as one of 24 pre-specified options strategies, including vertical spreads, butterflies, and straddles.

0DTE (Retail) Trading. We first show that 0DTE options are responsible for most of the overall growth in the trading activity in S&P 500 options. Today, more than 40% of all traded contracts expire on the same day. Most of these positions in ultra-short-term options are closed before maturity. End consumers buy more 0DTE options than

[3]The Q3-2023 earnings call transcript can be downloaded from https://investors.interactivebrokers.com/en/general/about/quarterly-earnings.php.

[4]We show that a cruder but more general identification of retail trades by the trade's size leads to similar conclusions.

they sell, which in turn leaves the option market maker with a net-short position. Using detailed Open/Close data, which breaks down each day's options volume by the market participant from which it originates, we can show that the aggregate net-short position of market makers in 0DTE options has grown considerably since the introduction of a daily expiration calendar in May of 2022.[5]

We next show that 0DTE options are particularly popular among retail investors. Overall, the share of retail trading in S&P 500 options fluctuates between 2% and 4%. For 0DTE options, this share exceeds 6%, and today around 75% of all retail trades in S&P 500 options are in 0DTE options. Retail investors have favored multi-leg positions in 0DTE options in 2021 but have gradually shifted towards favoring single-leg positions. Since mid-2022, single-leg positions represent between 60% and 80% of their volume. The most popular complex option strategies are put and call spreads, which are directional bets on the movement of the underlying with lower margin requirements than naked option positions. Retail investors also frequently place bets on the volatility of the underlying through (Iron) Condors and Butterflies. Strangles and Straddles are seldom used. Finally, we show that the proposed price improvement mechanism discussed in Cboe proposal SR-CBOE-2020-051 works: effective spreads for retail orders are significantly smaller than for the remaining 0DTE trades. Retail investors favor small order sizes, have a higher tendency of buying 0DTE options than the remaining market participants, favor a holding period of between 3 and 6.5 hours, and contracts that are at-the-money or slightly out-of-the-money.

Drivers of Retail Demand in 0DTE Options. What drives retail demand for 0DTE options? To answer this question, we proceed in two ways. First, we study the *time-*

[5] Dim, Eraker, and Vilkov (2024) and Brogaard, Han, and Won (2024) study the implications of the 0DTE inventory of market makers for S&P 500 options and how their hedging activity influences the volatility of the underlying index.

series evolution of the share of retail volume in 0DTE options, relative to the total trading activity: when are retailers particularly active in 0DTE options, relative to the trading activity of other market participants? Whenever the index is particularly volatile, retailers participate more in the market for 0DTE options on the S&P 500. A one standard deviation increase in the realized variance of the S&P 500 translates to an increase in the 0DTE retail share by 0.5%, from a baseline of roughly 5%. We find a similar result for the realized price range between the high and low prices of the S&P 500 index recorded for that day, relative to the day's closing price. Interestingly, realized skewness is unrelated to the trading activity of retailers in 0DTE options, contradicting some of the earlier findings on how lottery preferences of retail investors shape their trading decisions in options (Boyer and Vorkink, 2014). We also investigate if important macroeconomic event trigger an elevated trading activity by retailers. On the average FOMC announcement day in our sample, we find that the retail share in 0DTE options is 0.9% lower, suggesting that retailers do not specifically target exposure to these events, at least not in excess to the remaining market participants.

Second, conditional on the decision to trade 0DTE options, what are the determinants of retailers' decision to buy vs. to sell the respective contracts? For this, we regress a dummy indicating if a trade involved buying the option contracts on several trade characteristics. We can show that retail traders are more likely to buy options that are further in-the-money, as judged by the trade's absolute Δ. Furthermore, retail traders are more likely to buy particularly expensive options. On the flip side, we find that buys become less frequent as we approach the expiration of the options, and that trades with a larger size, as a measure of the trader's conviction, are significantly more likely sells than buys. Finally, we find a large impact of a trade involving complex option strategies on the retail trader's decision to buy or sell the respective strategy.[6] Trades involving multiple

[6] We infer the trade direction of complex strategies by comparing the synthetic mid price and the realized net price of the strategy following Li et al. (2023).

option contracts have an 18% higher probability of being a sell. This is consistent with more informed retail investors favoring the use of complex option positions to harvest the variance risk premium in 0DTE options, while maintaining lower margin requirements and less risky positions (Hu, Kirilova, Park, and Ryu, 2023).

Retail Traders Lose Money in 0DTE Options. We next investigate if the popularity of 0DTE options by retail investors is founded in the aggregate performance of their investments. The answer is a resounding "No": across our sample period spanning almost three years between February 2021 and September 2023, retail investors together lost more than $125 million. More than $90 million of these losses are the result of transaction costs, the remainder a result of poor positioning. Cumulative losses before considering transaction costs have remained relatively flat since November of 2022, whereas the overall losses including transaction costs continue to grow. Despite Cboe's price improvement mechanism, which we have shown to work well for retail traders, transaction costs for 0DTE options remain high and drive the majority of losses by retail investors. Comparing the profit and loss profile of single- and multi-leg trades, we find that aggregate losses are primarily driven by single-leg positions, on which retailers lost more than $100 million. These losses have picked up dramatically in mid-2022, which coincides with the introduction of a daily expiration calendar for S&P 500 options. While multi-leg trades also lose money on average, we find that their overall profits have plateaued since the beginning of 2023.

Retail losses from 0DTE options have grown over time, especially since the introduction of option expirations on every weekday. Average daily retail losses amount to $241,000 for the entire sample. This number has accelerated considerably in recent months. After May 16th, 2022, which marks the introduction of a daily expiration calendar by the Cboe, daily retail losses in 0DTE options have grown to $350,000. Roughly 70% of daily losses are the result of transaction costs and retail buys show particularly poor performance. We find that many multi-leg strategies deliver positive margin-adjusted returns. For example, the median return of put (call) spreads amounts to 3% (3.3%), which compares well to the negative margin-adjusted returns of the median single-leg option position. Some volatility strategies followed by retail investors also deliver positive returns.

Drivers of Retail Profits and Losses. We find that daily retail profits are elevated on days with a more volatile underlying index, measured by the S&P 500's realized price range. A one standard deviation increase in the price range corresponds to an increase in aggregate daily profits of \$30,000. Higher retail participation, in contract, is associated with significantly lower profits. Realized variance, which is driving much of the overall decisions of retailers to trade 0DTE options in the first place, and realized skewness show no significant relationship with aggregate profits. The same applies to FOMC announcement days: the aggregate profit of retail investors on FOMC announcement days is indistinguishable from the remaining days in our sample.

We next conduct a detailed trade-level analysis of the drivers of retail profits and losses in 0DTE options. We find that a higher expensiveness of the options considered, which we measure using the average implied volatility, leads to substantially lower returns. A one standard deviation increase in the implied volatility leads to a reduction in the trade's margin-adjusted net-of-fees return of 16.3bps. Coupled with the finding that retailers prefer *buying* particularly expensive option contracts, this suggests that their poor positioning contributes to their overall poor performance. In contrast, the trader's conviction, which we measure by the bid-ask spread at the time of initiating the trade, and the trade's overall size, is positively associated with the trade's profitability. We find some evidence that retail traders are neither compensated for taking on greater volatility nor jump risk, but that their trade's performance suffers. Finally, we find that complex multi-leg orders perform significantly better than single-leg trades, and that shorting single options but especially multi-leg strategies improves the retailer's performance substantially. We confirm these results in separate investigations of the performance drivers for different "clusters" of retail trades, including single-leg trades, trades involving put and call spreads as the dominant multi-leg strategy employed by retailers, and trades that bet on the volatility of the underlying index, including straddles, strangles, and (iron) condors and butterfly spreads.

Related Literature

Our paper adds to a growing literature analyzing the behavior of retail investors, and whether their trading decisions are on average profitable or not. Early studies on the topic suggest that retail investors make systematic mistakes and are generally uninformed (Barber and Odean, 2000, 2008). More recently, Eaton, Green, Roseman, and Wu (2022) show that the *absence* of Robinhood investors leads to improved market conditions. In contrast to these studies, Boehmer, Jones, Zhang, and Zhang (2021) build on a novel identification of retail investors from trade-level data and find that retail stock order imbalances predict future short-term stock returns. In line with this, Welch (2022) shows that the aggregate portfolio of Robinhood investors performs well and accredits retail investors some ability to time market movements. Boehmer and Song (2020) find that the short-selling activity of retail investors predicts negative stock returns. We add a comprehensive study of retail trading in ultra-short-term options on the S&P 500. We show that retail traders have a strong preference for options that expire on the same trading day, which is not founded in their aggregate performance. Furthermore, we find that retail traders make systematic mistakes in the selection of option contracts and their trades' direction. A subgroup of retail traders – those that favor complex multi-leg option strategies like vertical spreads and those that favor selling the respective strategies – performs considerably better in the market of 0DTE options on the S&P 500.

We also add to the literature on options trading by retail investors and lottery-like preferences of investors. Bauer, Cosemans, and Eichholtz (2009) show that retail investors use options primarily to gamble. Lakonishok, Lee, Pearson, and Poteshman (2007) uncover speculative purposes as the primary trading motive and Byun and Kim (2016) come to a similar conclusion. In line with this, Boyer and Vorkink (2014) show that skewness negatively predicts future option returns, which the authors attribute to intermediaries requiring greater compensation for facilitating the demand for lottery-like options (Bali et al., 2011). In contrast, our results find little influence of the realized skewness of the S&P 500 on the magnitude of the trading activity of retailers in 0DTE options. Instead, they are primarily guided by the overall volatility of the index.

The results of Lipson, Tomio, and Zhang (2023) suggest that the option trading activity of retail investors has the potential to increase the volatility in the underlying securities, and Blau, Bowles, and Whitby (2016) find a similar result for overall gambling demand in options. In a recent study, Bryzgalova et al. (2023) show how to identify retail trades in options using transaction-level data. The authors find that retail investors on aggregate lose money in single equity and ETF options. Furthermore, Eaton, Green, Roseman, and Wu (2024) show that retail option demand has an impact on the expensiveness of equity options, and Ernst and Spatt (2022) document large payments for order flow in the options market and limited evidence of price improvements for retail investors. Our study instead focuses on the rapidly growing market for options that expire on the same trading. These 0DTE options are particularly popular among retail investors and today represent more than 75% of all retail trading in S&P 500 options. Furthermore, we provide a comparative analysis of the profitability of retail trades in 0DTE options that involve a single options leg and trades that rely on complex options strategies with multiple contracts involved.

Only a handful of studies have so far looked at this new 0DTE options market. Brogaard et al. (2024) show that the rebalancing activity of option market makers due to their 0DTE exposure impacts the volatility of the S&P 500 index, while Dim et al. (2024) find no evidence of a propagation of moves in the underlying due to 0DTE options. Bandi, Fusari, and Renò (2024) introduce a pricing model for 0DTE options, and Vilkov (2024) studies the on-paper profitability of static option strategies, which involve 0DTE options. Finally, Londono and Samadi (2024) use 0DTE options to investigate the pricing of uncertainty around economic release dates, and Knox, Londono, Samadi, and Vissing-Jorgensen (2024) use 0DTE options to infer days important to the size of the equity risk premium. Given the drastic growth of the 0DTE options market, we require a thorough understanding of the market's dynamics and who participates in it. Our paper does so through the lens of retail traders.

2. Data

We use transaction-level data for S&P500 options provided by Cboe. Because S&P500 options are exclusively traded on Cboe exchanges, this covers their entire volume. Our dataset of intraday trade data starts in January 2005 and ends in September 2023. As our focus is on investigating the implications of retail trading in 0DTE options we restrict most of our analyses to the period between February 2021 and September 2023. We augment information about S&P500 option *trades* with high-frequency data on market maker *quotes*. Our analyses require us to classify trades into buys and sells. We consequently merge every transaction from the trade-level data with the last available bid and ask quotes. The trade direction is identified using the quote rule following Muravyev (2016), such that trades with prices above (below) the mid quote are classified as a *buy* (*sell*).

Transaction-level options data is noisy. We thus employ the set of filters proposed by Bryzgalova et al. (2023). Specifically, we remove canceled trades, trades with non-positive size, and trades with a negative bid-ask spread. Furthermore, we only consider those trades for which the trade price is above the prevailing best bid minus the bid-ask spread and below the best ask plus this spread. Should multiple trades enter at the same time and with the same trade ID, we handle them as a single trade.

3. The 0DTE Options Landscape

Panel A of Figure 1 shows the rising popularity of 0DTE options in recent years. We separately show the transacted volume in 0DTE options on the S&P 500 and all other maturities between January 2005 and September 2023. While 0DTE options have played a small role until 2018, they have since rapidly risen in popularity. Over the last five years, they have represented most of the overall growth in S&P 500 options trading.

Panel B of Figure 1 corroborates this finding. Here, we zoom in on the period since January of 2018 and show the monthly trading volume broken down by different maturity buckets. The entire growth in index options trading over this time period is amassed in short-term options with maturities of up to four days. The bulk of this increase is furthermore concentrated in options that expire on the same day. In fact, the volume in options with more than four days to maturity has slightly decreased since 2018. The increase in 0DTE options trading is particularly pronounced around and after May of 2022. This date marks the introduction of Tuesday and Thursday expirations for S&P 500 options. Since then, options on the S&P 500 expire on every weekday, such that investors can add ultra-short-term 0DTE options to their portfolios on every trading day.

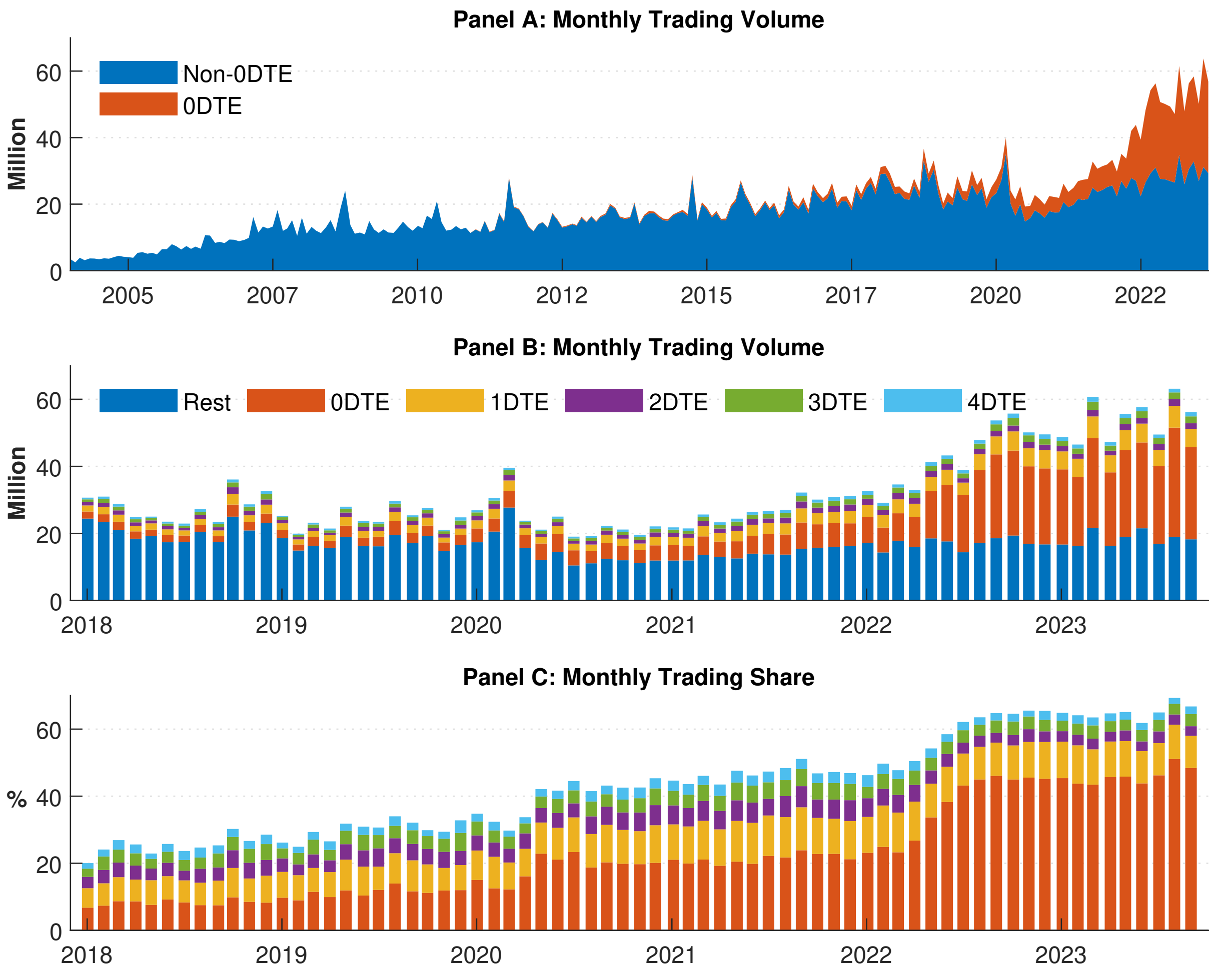

Fig. 1. Trading in S&P 500 Options Over Time

The figure shows the monthly trading volume and trading share in S&P 500 options across different option maturities. Panel A plots the total monthly trading volume from January 2004 until September 2023, split by 0DTE options and all remaining maturities. Panel B shows the monthly trading volume from January 2018 until September 2023 for short-term maturities (0 to 4 days to expiration) and the remaining maturities. Panel C plots the monthly trading share between January 2018 and September 2023 for short-term maturities (0 to 4 days to expiration).

Finally, we show the volume *share* by option maturity in Panel C of Figure 1. In 2018, options with a maturity of up to a week represented between 20%–30% of all transacted S&P 500 option contracts. This number has steadily grown since and today consistently exceeds 60%. Of this 60%, more than two thirds are represented by 0DTE options which have seen the largest increase in demand. Overall, there is a considerable demand for short-term and ultra-short term options exposure.

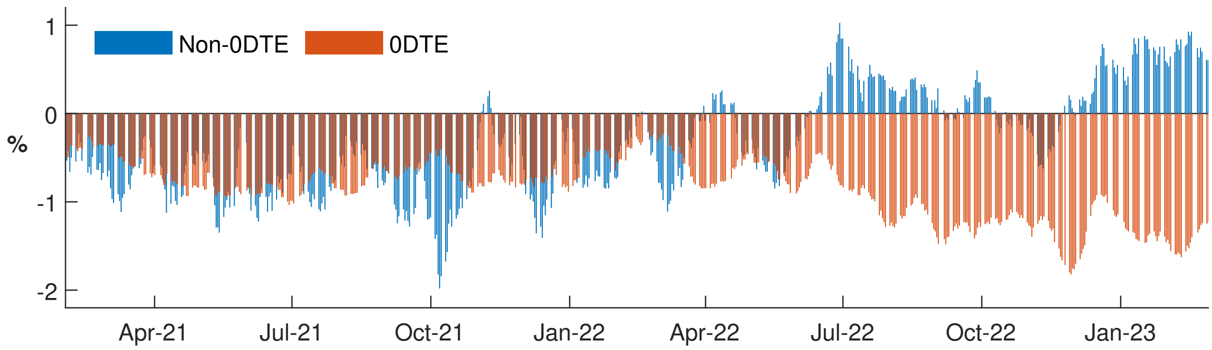

Fig. 2. 5-day moving average market maker order imbalance

The figure shows the 5-day moving average of the order imbalance of option market makers (see Eq. (1)) in 0DTE options on the S&P 500, as well as in all remaining maturities of options on the index, between February 2021 and February 2023.

Who provides the liquidity for this rapidly expanding market and consequently warehouses the associated risks of 0DTE options? It is well documented that market makers play a crucial role in option markets by providing liquidity and ensuring that there is a continuous supply of buyers and sellers for options (Garleanu, Pedersen, and Poteshman, 2009; Fournier and Jacobs, 2020). Accordingly, we provide a breakdown of the overall order imbalance of the aggregate option market maker over time in Figure 2. We use the trading activity of option market makers from the daily Open/Close profile obtained from Cboe for S&P 500 options, which informs us about the direction of the trades that involved a market maker. The market maker's relative order imbalance is consequently defined as the difference between the contracts she bought and sold on day t, normalized by the trading day's total volume,

$$OrdImb_t^{MM} = \frac{\sum_i Buy_{t,i}^{MM} - \sum_i Sell_{t,i}^{MM}}{\sum_i Volume_{t,i}^{Total}}, \tag{1}$$

where i denotes the option contracts. We separately show the order imbalance for 0DTE options in orange, and for the remaining maturities in blue.

Throughout the considered sample period from February 2021 to February 2023, we find that the 0DTE order imbalance of option market makers is consistently negative. It hovers between -0.5% and -1% up until the introduction of a daily expiration calendar in May of 2022. Afterwards, we find that it turns even more negative, and has since consistently dipped below -1%. End consumers have net-long demand for 0DTE options. Market makers consequently absorb this demand and hold a large short position in 0DTE options.[7] The market maker's order imbalance in the remaining maturities is also predominantly negative before the introduction of a daily expiration cycle in May of 2022. Afterwards, however, we find that it tends to turn positive, showing that end consumers demand more short positions in these options. As a consequence, since the beginning of a daily expiration cycle for S&P 500 options, we find that end consumers predominantly buy 0DTE options but sell the remaining maturities.

3.1. Retail Demand of 0DTE Options

The objective of this study is to analyze the implications of attracting more retail demand to 0DTE options on the S&P 500. Consistent with the overall growth in 0DTE trading, we find that 0DTE options have been a frequent discussion point by retail investors on Reddit's r/wallstreetbets.[8] Figure A1 plots the average number of daily mentions of '0DTE' or '0 DTE' in the most Subreddit's most active "Daily Discussion" and "What Are Your Moves Tomorrow" threads. 0DTE options are first mentioned at the end of 2018 but infrequently so. Throughout 2019 we observe a steady increase in the number of comments mentioning the topic. Right around the time of the Covid outbreak and mandated lockdowns worldwide we find a pronounced spike in the popularity of 0DTE options on r/wallstreetbets. The number of mentions reaches its peak in mid-2020 with

[7] To readers interested in how the 0DTE inventory held by market makers for S&P 500 options and the resulting hedging activity influences the volatility of the underlying index, we refer to Dim et al. (2024) and Brogaard et al. (2024).

[8] 0DTE options are also frequently discussed on other Subreddits, for example in r/Daytrading, r/thetagang, or r/options.

more than 25 comments devoted to the topic on the average day. Since then, the average number of daily mentions has hovered around 15–20, highlighting a large interest of retail investors to learn about and discuss 0DTE trading.

Identifying Retail Trades. To identify retail trades, we capitalize on the Cboe's recent decision to incentivize greater price improvements for small S&P 500 options orders. Cboe proposal SR-CBOE-2020-05 encourages greater retail participation in these options by activating Cboe's Automated Price Improvement Mechanism (AIM). As the Securities Industry and Financial Markets Association (SIFMA) notes in a letter issued on July 9, 2020, "this should incentivize increased retail customer auction participation in SPX options and provide retail customers with execution and price improvement opportunities in SPX options". Price improvements for smaller order sizes are thought to attract more retail flows. Of course, short-term options are particularly in line with retailers' desire to trade in smaller quantities: they appear cheap on paper, with low notional prices (Boulatov, Eisdorfer, Goyal, and Zhdanov, 2022).

The implementation of the proposed changes allows us to identify retail trades. Trades from retailers of an order size of up to 10 contracts, which is the maximum size for a single leg trade and also the maximum size permitted for the smallest leg of a multi-leg trade, enjoy price improvements. These trades appear in our transaction level data set with OPRA type descriptions SLAN, short for *Single Leg Auction Non Iso*, or MLAT, short for *Multi Leg Auction*, whenever a single order involves multiple option legs. Multi-leg option trades offer several advantages compared to "naked" option positions. Key among them is a defined risk profile, which typically results in lower margin requirements. Since margin requirements for retail investors are commonly calculated following Regulation T, naked option positions often bind considerable amounts of capital. Furthermore, Li et al. (2023) show that execution costs of multi-leg positions tend to be smaller in comparison to single-leg positions. Finally, multi-leg option positions offer complex payoff structures, and as a result allow investors to bet on the volatility of the underlying.

Using these development, we can identify that subset of retail trading in S&P 500 index options since February 22, 2021, which is internalized and enters the price improvement mechanism. Internalization in this context refers to the practice of so-called wholesalers buying retail order flow from retail brokerages and executing the respective orders against their own inventory. Although these wholesalers may decide to internalize only a fraction of the retail order flow they buy and route the remainder to Cboe as the exchange for S&P 500 options, identifying the internalized fraction allows us to directly study the implications of the proposals by Cboe to attract more retail demand. Furthermore, anecdotal evidence gives credence to our identification approach: in their Q3-2023 earnings call, executives of major retail broker Interactive Brokers were asked about the recent growth in 0DTE options trading by retail investors. Specifically referring to how they deal with this order flow, they responded with "[...] The way we participate, and our customers participate in these zero-day options – expiring options – is that we often send the customer orders into price improvement auctions."[9]

Several other studies have used the aforementioned strategy to identify retail trades from transaction level data. Bryzgalova et al. (2023) show for the broader market that the identification of single-leg retail trades by trade type SLAN works better than heuristics that rely on small order volumes. The studies by Ernst and Spatt (2022) and Hendershott, Khan, and Riordan (2022) use the same approach to identify retail trades involving a single option leg. Different from these studies, we also consider multi-leg strategies. Hu et al. (2023) show for the Korean options market that retail investors that favor complex strategies make more profitable investment decisions. We investigate if the use of complex

[9] The Q3-2023 earnings call transcript can be downloaded from https://investors.interactivebrokers.com/en/general/about/quarterly-earnings.php.

options strategies also improves the overall performance of retail traders in the market for short-term U.S. index options.

0DTE Options Are Popular Among Retail Investors. So far, we have looked at the overall volume of S&P 500 options and its composition. Trading in ultra-short-term options has grown considerably since 2020. From now on, our focus is on retail trading in 0DTE options. Panel A of Figure 3 shows the evolution of retail trading in 0DTE options, as well as in all other maturities. During the period for which we can identify retail trades (January 2021 – September 2023), their trading in S&P 500 options has grown steadily. Roughly half a million contracts were traded by retailers in an average month in the first half of 2021, which has increased to more than a million contracts by early 2022. Since the introduction of Tuesday and Thursday expirations for S&P 500 options in May of 2022 retail volume regularly exceeds 1.5 million contracts per month. In fact, most of the growth in retail trading of index options is attributable to 0DTE options. Today, more than a million 0DTE contracts are routinely bought or sold by retail investors per month.

Panel B provides a breakdown of how important retail trading is for the overall market of S&P 500 options. We separately consider 0DTE options and options with a maturity of at least one day. Across all maturities, retail trades make up roughly 2% of all volume in 2021. This number has grown to about 4% today. For 0DTE options, retail investors play an exaggerated role: in 2021, roughly 4% of all 0DTE volume was transacted for and by retail accounts; in 2022 the retail share in 0DTE options exceeds 6%. The share in non-0DTE options, in contrast, hovers close to 2% for our entire sample. Finally, we show the fraction of retail volume that can be ascribed to 0DTE options in Panel C of Figure 3. Growing from roughly 30% in the beginning of 2021, 0DTE options today represent about three quarters of all retail trading in S&P 500 options.

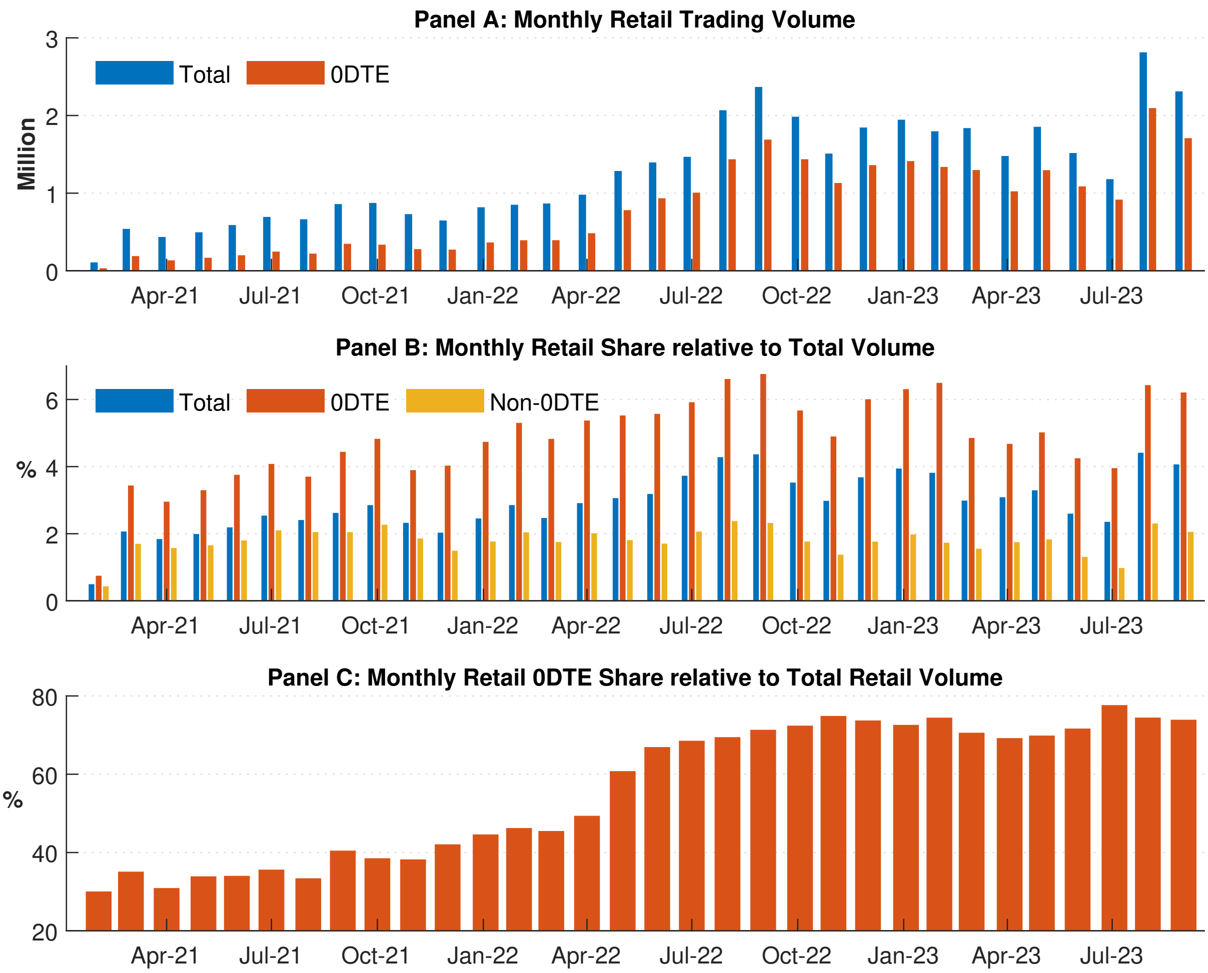

Fig. 3. Retail Trading in S&P 500 Options

This figure shows the monthly retail trading volume and retail share in options on the S&P 500 between February 2021 and September 2023. Panel A shows the monthly retail trading volume for all S&P 500 and for 0DTE options in particular. Panel B shows the monthly retail share of the overall trading volume for all S&P 500 options, and separately for their trading activity in 0DTE options and all remaining maturities. Panel C shows the monthly retail trading volume in 0DTE S&P 500 options as a fraction of their overall trading activity in options on the S&P 500.

In Figure 4, we show the decomposition of retail volume in 0DTE options. The share of single-leg options has grown considerably, from less than 20% in 2021 to more than 60% today. Judging by the large fraction of retail trades involving multiple option contracts, this shows that it is vital to not only consider single-leg trades but also retail trades that involve multi-leg positions, as these represent the majority of retail trading at the beginning and about a third at the end of our sample. To identify which strategies are

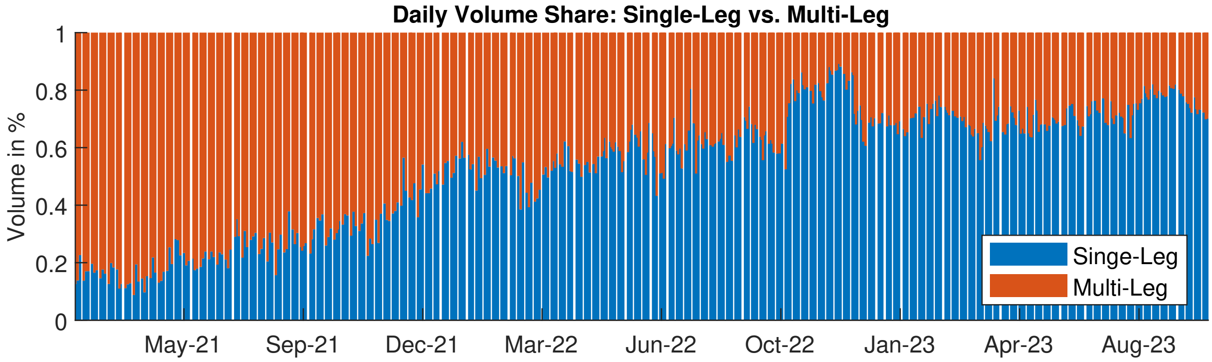

Fig. 4. Single- vs. Multi-Leg Strategies Followed by Retail Traders

The figure shows the relative share of retail trades in 0DTE options on the S&P 500 that involve a single option leg (buying or selling puts and calls) vs. retail trades that involve multiple option legs (so-called complex option strategies, such as put or call spreads, or butterfly spreads). The sample period runs from February 2021 to September 2023.

followed by retail investors, we use the identification algorithm developed by Li (2020). Specifically, we collect all trade entries with trade type MLAT that occur in the same millisecond, and check if the chosen strikes represent a known options strategy. This allows us to differentiate simple Bull and Bear Spreads from Iron Condors or Butterflies.[10]

Figure 5 shows the 11 multi-leg trading strategies most commonly used by retail investors. Because of the granularity of our dataset, we can also identify skip-strike Butterflies and Iron Condors, which feature a different risk profile and allow for a skewed bet on up- vs. downside volatility. We find that Put and Call Spreads are the dominant multi-leg strategies and represent roughly 70% of the multi-leg volume of retail investors in 0DTE options. Using options at two strike prices, these strategies allow investors to bet on the direction of the price of the S&P 500 index, while having significantly reduced margin requirements compared to single-leg options. Apart from directional exposure through put and call spreads, we find that bets on volatility are also frequently used by retail traders, representing the remaining 30% of multi-leg strategies employed by retail traders. (Iron) Condors and Butterflies feature a predefined risk exposure and lowered

[10] In total, we can classify 97.99% of all multi-leg retail trades as one of 24 pre-specified options strategies. A full breakdown is provided in Appendix C.

margin requirements, which are two characteristics favored by retail traders when employing multi-leg strategies. Strangles and Straddles, with undefined up- or downside exposure, are in contrast seldom used.

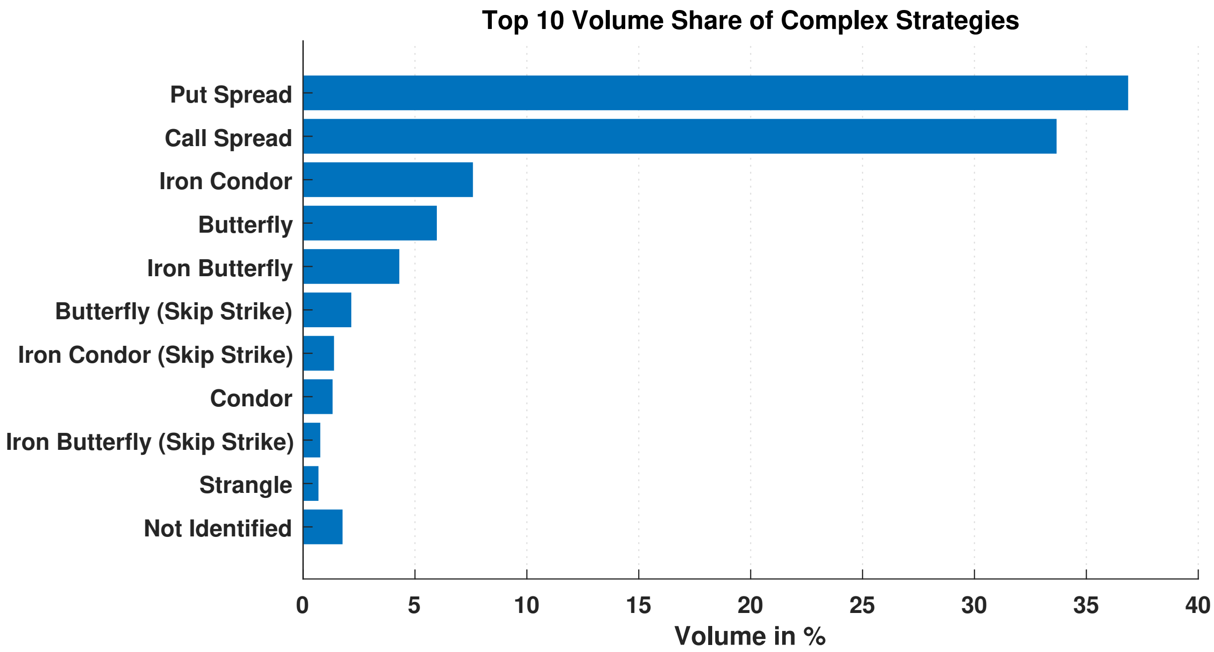

Fig. 5. Complex Option Strategies Employed by Retail Traders

The figure shows the volume share of the 10 multi-leg option strategies most followed by retail investors in 0DTE options for the sample from February 2021 to September 2023. We also show the fraction of trades involving multiple option legs that we cannot assign to one of the 24 predefined complex option strategies. A more detailed breakdown is shown in Appendix C.

We next take a closer look at the trading decisions in 0DTE options for retail investors and non-retail investors. We investigate whether the two investor groups differ systematically in their contract choice, trade sizing, chosen holding period and trade direction. For that, Table 1 shows the number of trades and total volume, split by several option characteristics, including the option type, the order size in contracts and the trade direction, as well as the option's hours-to-maturity and moneyness. We also show the average quoted and effective spreads. For this, we define the quoted and effective spread of trade j as:

$$\mathrm{QS}_j = \frac{Ask_j - Bid_j}{Mid_j}, \qquad \mathrm{ES}_j = \frac{|Trade\ Price_j - Mid_j| \times 2}{Mid_j}. \tag{2}$$

Table 1: Retail vs. Non-Retail Trading in 0DTE Options on the S&P 500

The table shows a breakdown of the characteristics of trades in 0DTE options on the S&P 500 from price improvement auctions (Retail) and the remainder executed electronically (Non-Retail). The sample covers the period between February 2021 and September 2023. The quoted and effective spreads are measured as in Eq. (2), and moneyness is defined as the absolute Delta at the time of the trade.

		0DTE Retail				**0DTE Non-Retail**			
Characteristic	Category	Freq. (%)	Volume (%)	QS (%)	ES (%)	Freq. (%)	Volume (%)	QS (%)	ES (%)
Type	Call	48.9	49.0	9.9	5.7	49.6	48.7	17.0	10.4
	Put	51.1	51.0	8.7	4.8	50.4	51.3	14.5	7.9
Size	1	62.5	26.9	8.5	5.1	48.1	9.2	13.8	8.2
	2 - 5	28.5	37.7	10.3	5.5	31.8	18.7	16.4	9.5
	6 - 10	8.9	34.7	11.3	5.8	11.0	18.0	17.8	9.9
	11 - 100	0.1	0.7	19.8	7.9	8.9	44.4	20.1	11.9
Direction	Buy	40.1	39.7	9.8	7.7	37.3	38.4	21.0	17.7
	Sell	41.2	42.4	9.1	5.3	44.9	46.7	12.0	5.6
	Mid	18.8	17.9	8.4	0.0	17.8	14.9	13.9	0.0
TTM	1 hour	12.7	13.0	16.5	10.1	15.5	16.0	27.0	18.2
	1 - 3 hours	24.7	25.2	9.7	5.7	24.6	24.7	16.2	9.4
	3 - 6.5 hours	61.7	60.7	7.7	4.1	57.5	56.1	12.8	6.9
Moneyness:	$0.125 \geqslant \lvert\Delta\rvert$	28.2	29.7	22.3	13.4	37.8	45.5	34.3	20.6
	$0.125 < \lvert\Delta\rvert \leqslant 0.375$	40.2	38.2	5.0	2.6	34.9	31.2	5.2	2.7
	$0.375 < \lvert\Delta\rvert < 0.625$	25.0	25.2	3.0	1.5	20.2	17.0	3.2	1.6
	$0.625 \leqslant \lvert\Delta\rvert < 0.875$	5.3	5.5	3.5	1.1	5.5	4.8	3.9	1.6
	$0.875 \leqslant \lvert\Delta\rvert$	1.3	1.3	3.2	0.6	1.6	1.6	3.6	1.0

To make single- and multi-leg trades comparable, we consider the average spread of the contracts included in the multi-leg strategies.

We first confirm that the proposed price improvement mechanism works. Consistent with Cboe's stated objective of attracting additional retail demand by providing price improvements in the order execution, we show in Table 1 that retail investors benefit from substantially lower spreads, compared to trades that originate from non-retail investors. On average, they pay an effective spread of 5.7% for calls and 4.8% for puts, compared to 10.4% and 7.9% paid by non-retailers for the average call and put trade, respectively.

We find that retailers and non-retailers both trade 0DTE put and call options on the S&P 500 with roughly equal frequency, which stands in contrast to Bryzgalova et al. (2023) who document a clear preference of retail investors for call options on single stocks. Retail investors favor small order sizes, with almost two thirds of their orders trading a single option or a single multi-leg position. 28.5% trades involve between 2 and

5 contracts, 8.9% between 6 and 10, and just 0.1% of all trades involve more than 10 contracts.[11] In contrast, non-retail orders in 0DTE options frequently exceed a size of 10 contracts, such that 44.4% of their volume falls in this category.

On average we find that retail investors are more likely to buy 0DTE options than non-retailers. We identify 40.1% (41.2%) of retail trades as buys (sells) compared to 37.3% (44.9%) of non-retail trades. The remaining trades are executed at the prevailing mid-quote. Effective spreads are significantly lower for sell orders, consistent with the evidence in Figure 2 that the order imbalance of the option market maker is consistently negative in 0DTE options. The market maker happily facilitates sell orders of both retail and non-retail investors, which brings her overall imbalance in 0DTE options closer to neutral. This is indicative evidence that option market makers are actively managing their large negative order imbalance in 0DTE to limit the associated risks.

Both retail and non-retail investors tend to enter their 0DTE option positions in the first half of the trading day with between 3 and 6.5 hours left until the expiration of the contracts at 4pm Eastern time. 61.7% of retail trades and 57.5% of non-retail trades occur during this time. Interestingly, both retail and non-retail investors continue to trade 0DTE options with less than an hour until expiration. As the option approaches expiration, we find that effective and quoted spreads widen but that the price improvement enjoyed by retailers continues to cut effective spreads in half.

Finally, we document that retail traders heavily favor at-the-money contracts, with an absolute Δ between 0.325 and 0.625, and contracts slightly out-of-the-money, where $0.125 < |\Delta| \leq 0.375$. These options represent roughly 75% of their trades and transacted volume, compared to 65% and 48% for non-retailers. Interestingly, we find that retailers

[11] We can identify a small fraction of retail trades that involve more than 10 contracts but still fall under the price improvement mechanism. Given that the price improvement mechanism is applied to all multi-leg strategies for which the number of contracts traded in the *smallest* leg does not exceed ten, this includes multi-leg strategies with an uneven distribution of contracts per leg, such as butterfly spreads.

also frequently trade deep out-of-the-money 0DTE options (28.2% of their trades), but less often than the remaining market participants (37.8% of their trades). In-the-money options are in contrast seldom used by both investor groups.

Drivers of 0DTE Retail Demand. What drives the documented demand in 0DTE options of retail traders? To answer this question, we proceed in two ways. As a first step, we relate the aggregate share of retail volume in 0DTE options, relative to the total trading activity in these options, to measures possibly linked to their aggregate decisions to partake in the market for 0DTE options. We include the realized variance of the S&P 500 measured for each day, its realized skewness to investigate if preferences for skewness drive retail demand (Boyer and Vorkink, 2014), and the realized price range of the index, measured as the difference between the intraday high and low. Furthermore, we include a dummy for FOMC announcements that fall within our sample period. With this, we want to investigate if important macroeconomic events trigger an elevated trading activity by retailers, to see if they actively seek exposure to such events.

The results in Table 2 show that retail investors are particularly active in 0DTE options on the S&P 500, whenever the index is particularly volatile. A one standard deviation increase in the realized variance of the S&P 500 translates to an increase in the 0DTE retail share by 0.51%, from a baseline of 5.1%. We find a similar result for the overall range of the S&P 500 index, such that a one standard deviation increase in the price range translates to additional retail participation of 0.24% of the aggregate volume. Interestingly, realized skewness is unrelated to the trading activity of retailers in 0DTE options, contradicting some of the earlier findings on how lottery preferences of retail investors shape their trading decisions in options (Boyer and Vorkink, 2014). We instead find that the overall variation of the underlying is most important and can explain roughly 17% of the variation in the relative trading activity of retail investors in 0DTE options. We also

Table 2: Determinants of the Share of Retail Trading in 0DTE Options on the S&P 500

The table shows the results of regressing the daily share of retail trading in 0DTE options on various characteristics of the underlying S&P 500. RVar is the logarithm of the realized variance calculated using one-minute intraday returns, RSkew is the realized skewness as in Amaya, Christoffersen, Jacobs, and Vasquez (2015) calculated using one-minute intraday returns of the S&P 500. Range denotes the difference between the realized intraday high and low prices of the S&P 500. FOMC is a dummy that equals 1 on FOMC announcement days. We standardize RVar, RSkew and Range, and include fixed effects for the day of the week. The t-statistics are given in parentheses and are calculated using Newey and West (1987) standard errors with optimal lag length.

	(1)	(2)	(3)	(4)	(5)
Intercept	5.106	5.106	5.106	5.141	5.041
	(61.1)	(53.4)	(55.5)	(61.1)	(46.7)
RVar	0.505			0.534	0.514
	(7.5)			(7.9)	(7.8)
RSkew		0.033		-0.003	0.006
		(0.7)		(-0.1)	(0.2)
Range			0.204		
			(2.9)		
FOMC				-0.895	-0.848
				(-4.0)	(-3.4)
adj. R^2 (%)	17.29	-0.11	2.67	18.97	20.74
Day of Week FE	No	No	No	No	Yes

find no evidence that retail investors actively seek exposure to FOMC announcements, at least not in excess to the demand by the remaining market participants. In fact, on the average FOMC announcement day in our sample, we find that the retail share in 0DTE options is between -0.85% and 0.90% *lower*.

As a second step to investigate the drivers of retail demand, we zoom in on the level of individual trades. Whereas Table 2 shows how the aggregate retail demand responds to characteristics of the underlying index and the presence of macroeconomic announcements, Table 3 analyzes how the trade-level decision to buy or sell the selected contracts is linked to each trade's characteristics. For this, we regress a dummy indicating if a respective trade involved *buying* the option contracts on the trade's moneyness, approximated by the absolute Delta, the trade's time to maturity measured in hours, its expensiveness measured by the average implied volatility of the contracts traded, and whether the trade established a complex strategy, which involves multiple option contracts. We also incorporate the number of options traded, following the idea that larger trades signal a greater conviction of the retail trader. For multi-leg positions, we record the average implied volatility of the option contracts involved, weighted by the number of contracts, the trade's absolute Delta, taking into account the trade direction in the respective contracts (buy vs. sell), and the number of multi-leg positions traded as the trade's size. For comparability, we standardize non-dummy variables.

Table 3: Drivers of the Chosen Trade Direction of Retail Traders

The table shows the results of regressing a dummy that equals 1 if a trade bought the underlying contract or multi-leg options strategy on several trade-specific characteristics. To infer the trade direction of complex option strategies, we follow Li et al. (2023) and compare the synthetic mid price with the realized net price of the strategy. We include each trade's absolute Delta, time to maturity (TTM), average implied volatility, the number of contracts traded (Trade size), and a dummy (Complex) that equals 1 if the trade involves multiple legs. We standardize Delta, Gamma, Vega, and IV and include day fixed effects. The t-statistics are given in parentheses and are calculated using standard errors clustered by day.

	(1)	(2)	(3)	(4)
|Delta|	1.339	1.563	1.520	-0.132
	(18.16)	(21.91)	(21.68)	(-2.15)
TTM	-1.107	-1.032	-1.059	-1.020
	(-16.28)	(-14.33)	(-14.81)	(-16.06)
IV		4.328	4.343	4.643
		(18.62)	(18.65)	(18.72)
Trade size			-1.026	-0.390
			(-34.90)	(-17.83)
Complex				-18.130
				(-81.96)
adj. R^2 (%)	0.39	0.56	0.60	1.96
Day FE	Yes	Yes	Yes	Yes

We can show in Table 3 that retail traders are more likely to buy options that are further in-the-money, as judged by the trade's absolute Δ. Interestingly, we also find that retail traders are more likely to buy options with a larger implied volatility. A one standard deviation increase in the implied volatility triggers an elevation of the probability of the trade being a buy by between 4.3% and 4.6% depending on the regression's specification.

On average, we find that selling options with elevated higher implied volatilities would have resulted in more profitable trades during our sample period, suggesting that retailers have a tendency to purchase particularly expensive contracts.

On the flip side, we find that the contracts' hours to maturity are negatively related to the probability of the trade being a buy. A one standard deviation increase in the time to maturity translates to a 1% lower buy probability. The same applies to the trade size: larger trades, as a crude measure of the retailers conviction in the trade, are more likely sells than buys. Finally, we find a large impact of a trade involving complex option strategies on the retailer's decision to buy or sell the respective strategy.[12] Trades involving multiple option contracts have a 18.1% *lower* probability of being a buy. This is consistent with more informed retail investors favoring the use of complex option positions to harvest the variance risk premium in 0DTE options, while maintaining lower margin requirements and less risky positions. In the next section we will investigate if these differences in the positioning of retail investors in single- vs. multi-leg trades impacts their aggregate profitability.

4. Profitability of 0DTE Trades

Is the popularity of 0DTE by retail investors founded in the success of their aggregate trading activity in these options? We document that retail investors consistently lose money, especially after transaction costs. Consistent with the idea that more informed investors choose more complex positions better suited to impound the information they possess, we find that multi-leg option trades of retail investors fare better than their single-leg positions. However, in the aggregate, retail investors lose in both single- and

[12]We infer the trade direction of complex strategies by comparing the synthetic mid price and the realized net price of the strategy following Li et al. (2023).

multi-leg positions. Finally, we investigate which characteristics lead to profitable trades, both in the aggregate and at the level of individual trades.

4.1. Retail Investors Lose Money With 0DTE Options

We follow Bryzgalova et al. (2023) and compute the dollar profits of the jth retail trade as follows:

$$\$Profit_j = Direction_j \times Size_j \times 100 \times (Payoff_j - O_j), \tag{3}$$

where *Direction* is +1 for buys and −1 for sell orders, *Size* the trade's order size in contracts and 100 the contract multiplier of S&P 500 options. Finally, *Payoff* is the option's payoff at maturity, i.e., $\max(S_{\text{settlement}} - K)$ for calls and $\max(K - S_{\text{settlement}})$ for puts, with the value of the S&P 500 at settlement, $S_{\text{settlement}}$. Thereby, we implicitly assume that the contracts are held to expiration, unless we observe an offsetting trade record.

We evaluate the trade's gross and net profits separately. To compute its gross profit, we set O_j to the prevailing mid-quote at the time of the trade. For its net profit, we use the actual transaction price, which we can observe in our trade-level dataset. This gives us a comparison of the aggregate profits of retail trading in 0DTE options before and after transaction fees paid to the market maker.

We show the cumulative net and gross profits in Panel A of Figure 6. There is little movement in 2021 but the cumulative profits especially net-of-fees are already negative. At the end of 2021 and until around May of 2022, aggregate gross profits turn positive for a while, but profits net-of-fees continue to stay negative. May of 2022 is when things turn bleak: gross profits dip into negative territory and stand at around −\$30 million at the end of our sample. Profits net-of-fees performed much worse and exceed −\$125 million by September 2023. Whereas cumulative gross profits remain flat after November

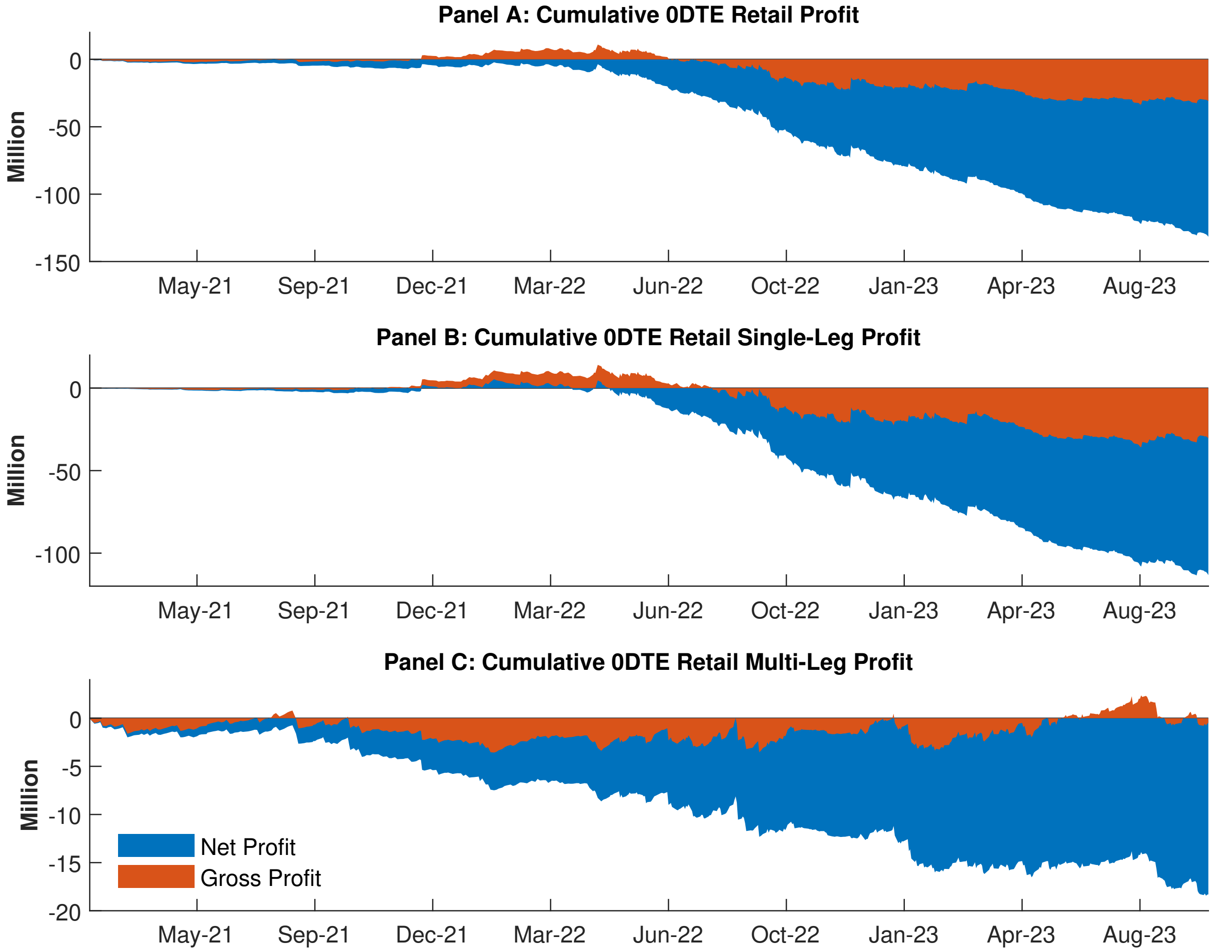

Fig. 6. Cumulative Daily Profits of Retail Trading in 0DTE Options

The figure shows the cumulative daily profits of the aggregate retail trading activity in 0DTE options on the S&P 500 following the definition in Eq. (3) between February 2021 and September 2023. We separately show the profits gross-of-fees (not considering the impact of transaction costs paid, as the deviation between the trade's price and the prevailing mid-quote) and the profits net-of-fees. Panel A shows the overall profits of retail investors, Panel B their profits in single-leg positions, and Panel C in multi-leg positions.

of 2022, reflecting a sensible choice of contracts by retailers, net profits continued to fall, showing the impact of spreads paid by retail investors. The figures presented here of course disregard commissions paid to the brokerage, as well as exchange and clearing fees. While brokers like Robinhood charge no commission on option trades, regulatory and clearing fees are still passed through to the investor.[13] Non-discount brokers, like

[13]At the time of writing this paragraph, regulatory fees at Robinhood stood at 1 cent and clearing fees at 2 cents per contract.

Interactive Brokers, continue to charge commissions per contract, with a minimum of $1 per order. Unfortunately our data does not allow us to identify the brokers used to route the retail orders. In a simple back-of-the-envelope calculation, however, commissions would have represented additional costs for retail investors of more than $600,000 in September 2022 alone, if all trades had been facilitated by Interactive Brokers.

In Panels B and C of Figure 6, we separately show cumulative net and gross profits of single-leg and multi-leg retail trades in 0DTE options. From the two panels, we note two interesting differences between retail trades in 0DTE options which involve a single option, and complex option strategies: First, consistent with Figure 4, retailers have favored multi-leg strategies for the first part of the sample and have gradually switched to a preference for single-leg option trades. Second, while both aggregate single- and multi-leg profits are negative for most of our sample, we find that multi-leg profits are more stable especially after the introduction of a daily expiration calendar in May of 2022. From that point onward, single-leg profits show a clear downward trajectory, both net and gross of fees. In contrast, for multi-leg trades, we find that net losses have slowed down since the beginning of 2023 and have remained remarkably stable since then.

We provide a detailed breakdown of aggregate retail profits in Table 4. On the average day, retail investors have lost $241,000 and since May 16th of 2022 $350,000 on 0DTE trades. Panel C shows average daily profits per month. Consistent with the evidence in Figure 6, profits and losses fluctuate little in 2021. Accompanying the overall growth in retail interest, the swings in 0DTE profits and losses are significantly larger in all of 2022 and 2023. For example, in January of 2022, the aggregate retail trading in 0DTE options generated $286,000 per day and after fees. Instead, in September of 2022 their aggregate trading lost $680,000 per day. Since the introduction of daily expirations in May of 2022, net profits have turned consistently negative. June, September and December 2022, and April 2023 mark the months with the largest retail losses caused by 0DTE exposure.

Table 4: Breakdown of Daily Profits of Retail Trading in 0DTE Options

The table shows the average daily profits in $100,000 of the aggregate retail trading activity in 0DTE options on the S&P 500 following the definition in Eq. (3) between February 2021 and September 2023. We separately show the profits gross-of-fees (not considering the impact of transaction costs paid, as the deviation between the trade's price and the prevailing mid-quote) and the profits net-of-fees. Panel A reports the daily average net and gross profits for the entire sample from February 2021 until September 2023; panel B for the period starting with a daily expiration calendar for options on the S&P 500 from May 16, 2022 until September 2023; panel C reports the daily average profits by month, panel D by weekday and panel E by trading hour.

	Net Profits			Gross Profits		
	All Options	Debit	Credit	All Options	Debit	Credit
Panel A: Full Sample						
	-2.41	-3.64	1.22	-0.57	-2.69	2.13
Panel B: From 16 May 2022						
	-3.50	-8.05	4.55	-1.06	-6.79	5.73
Panel C: By Month						
Feb-21	-2.47	-0.08	-2.39	-2.06	0.10	-2.15
Mar-21	-1.11	2.36	-3.47	-0.73	2.51	-3.24
Apr-21	-0.08	-0.74	0.65	0.12	-0.66	0.78
May-21	-0.62	0.09	-0.71	-0.25	0.24	-0.49
Jun-21	-0.00	-1.01	1.01	0.35	-0.87	1.22
Jul-21	0.36	-0.69	1.05	0.90	-0.45	1.35
Aug-21	-1.40	1.52	-2.92	-1.01	1.70	-2.70
Sep-21	-0.65	-3.32	2.67	0.17	-2.96	3.13
Oct-21	-1.05	1.57	-2.61	-0.22	1.95	-2.17
Nov-21	0.64	1.40	-0.76	1.38	1.76	-0.38
Dec-21	0.13	12.78	-12.65	0.97	13.18	-12.21
Jan-22	2.86	33.40	-30.54	4.19	34.08	-29.89
Feb-22	-1.05	-5.25	4.20	0.39	-4.53	4.92
Mar-22	-1.44	5.05	-6.49	-0.32	5.62	-5.95
Apr-22	1.29	24.97	-23.68	2.72	25.75	-23.02
May-22	-4.00	-19.13	15.12	-2.04	-18.10	16.05
Jun-22	-5.36	-12.15	6.80	-3.44	-11.18	7.74
Jul-22	-2.42	0.78	-3.20	-0.52	1.74	-2.26
Aug-22	-4.72	-10.93	6.21	-2.48	-9.78	7.30
Sep-22	-6.80	-17.00	10.19	-3.46	-15.26	11.80
Oct-22	-4.74	-12.36	7.62	-1.65	-10.73	9.08
Nov-22	-0.59	5.76	-6.35	1.98	7.15	-5.17
Dec-22	-5.77	-29.01	23.24	-3.08	-27.59	24.50
Jan-23	-2.45	12.78	-15.23	0.42	14.28	-13.86
Feb-23	-4.66	-24.92	20.27	-1.69	-23.35	21.66
Mar-23	-1.62	4.26	-5.88	0.71	5.45	-4.74
Apr-23	-5.07	-0.73	-4.34	-3.15	0.24	-3.39
May-23	-3.82	-22.74	18.92	-1.72	-21.68	19.96
Jun-23	-1.01	-7.93	6.92	0.81	-7.01	7.82
Jul-23	-3.33	-1.22	-2.11	-1.81	-0.45	-1.35
Aug-23	-1.48	10.87	-12.35	1.65	12.46	-10.81
Sep-23	-4.06	-21.74	17.68	-1.24	-20.32	19.08
Panel D: By Weekday						
Mon	-2.43	-10.57	8.13	-0.96	-9.82	8.86
Tue	-4.29	-15.23	10.94	-2.06	-14.07	12.01
Wed	-1.36	-3.39	2.03	0.32	-2.54	2.86
Thu	-2.37	16.13	-18.49	-0.00	17.34	-17.34
Fri	-2.36	-1.86	-0.50	-0.54	-0.93	0.39
Panel E: By Hour						
9:30	-0.46	-0.38	-0.07	-0.19	-0.25	0.06
10:00	-0.50	-0.60	0.10	-0.10	-0.39	0.30
11:00	-0.31	-0.72	0.41	-0.05	-0.59	0.54
12:00	-0.22	-0.44	0.22	-0.01	-0.34	0.32
13:00	-0.36	-0.40	0.04	-0.15	-0.29	0.14
14:00	-0.28	-0.58	0.31	-0.03	-0.46	0.43
15:00	-0.30	-0.52	0.22	-0.05	-0.39	0.34

Retail investors lost north of $500,000 on the average day. Gross profits are occasionally positive during 2022 and 2023, for example in April of 2022 or January of 2023, but in most months they are also negative.

Differences in profits are much more pronounced between buy and sell orders. While long positions in options lose money on average, short positions are profitable even after fees. However, the losses on long positions exceed the gains made from shorting and end consumers are predominantly long (see Figure 2), turning the aggregate retail profits – both net- and gross-of-fees – negative. The profitability of the short positions suggest that some retail investors harvest the variance risk premium (Coval and Shumway, 2001). Selling insurance against (ultra-short-term) variance risks is profitable on average, and our results suggest that some retail investors follow the strategy of providing insurance to other market participants. Over the full sample period, we find that retail investors on the average day lost \$364,000 on their debit orders after transaction costs, and made \$122,000 on their credit orders. In the aggregate, however, retail investors favor debit orders, such that their aggregate profits are negative.

Panel D provides the average profit-and-loss profile for each day of the week. Net profits are on average negative Monday through Friday. For example, on the average Tuesday, retail investors lost \$429,000. In general, we find that retail trades lead to a loss on average on each weekday. Finally, Panel E summarizes the dollar profits by trading hour on the 0DTE options' expiration day. Net and gross profits are negative throughout the trading day. We again find that retail investors lose on their buy orders and make money on their sell orders.

Profitability by Strategy. Our identification approach allows us to differentiate retail trades with a single option from complex orders with multiple legs. Hu et al. (2023) show for the Korean options market that more informed investors tend to favor complex option trades. In Table 5, we therefore document the distribution of net profits broken down by option strategy. From the table we learn that the average retail trade using a single put (call) loses \$16.3 (\$20.7). Median profits for both are also negative with a wide distribution of net profits. For example, the interquartile range for put options is from a loss of −\$482 to a profit of \$410. Interestingly, while *average* profits for put and call spreads are also negative, profits of the average trade (Median) are both positive at \$85. For both strategies, the absolute of the profits at the 75th percentile also exceeds those at the 25th, suggesting that the average gain trade is more profitable than the average loss trade. Turning to the more complex strategies, like Iron Condors and Butterflies, we find that the median trade of many strategies is indeed profitable. Average profits instead are mostly negative, driven by a few negative outliers.

Table 5: Profits of Retail Trading in 0DTE Options by Strategy Employed

The table shows summary statistics of the net-of-fees dollar profits of retail investor trades between February 2021 and September 2023, broken down by the trade's strategy. The identification of multi-leg strategies follows Li (2020). We show the frequency with which retail investors chose a particular strategy (Volume), the mean net profits in dollars, as well as the 5th (P5), 25th (P25), 50th (Median), 75th (P75), and 95th (P95) quantile of net dollar profits.

Strategy	Volume (%)	Mean	P5	P25	Median	P75	P95
Put	34.1	-16.3	-3300.0	-482.0	-35.0	410.0	3210.0
Call	31.3	-20.7	-3008.0	-455.0	-35.0	388.0	2928.0
Put Spread	12.7	-20.2	-2095.0	-260.0	85.0	350.0	1700.0
Call Spread	11.6	-15.8	-2070.0	-260.0	85.0	360.0	1700.0
Iron Condor	3.6	-15.6	-2228.5	-213.0	135.0	420.0	1570.0
Butterfly	3.2	-13.4	-1410.0	-240.0	-30.0	220.0	1394.0
Iron Butterfly	2.0	-26.2	-3501.1	-710.0	-20.0	765.0	3348.0
Condor	0.8	15.1	-1889.5	-240.0	59.0	335.0	1645.5
Strangle	0.3	-40.0	-3847.2	-760.0	22.0	650.0	3977.6
Straddle	0.3	-59.5	-4709.1	-1057.3	-56.0	1003.3	4282.3

Dollar profits are difficult to compare across option strategies, as the strategies' margin requirements, which denote how much capital is bound by a trade, differ substantially. We follow Cboe's Margin Manual to calculate the margin requirements for 0DTE retail trades in our sample.[14] From that, we calculate a trade's margin-adjusted returns as:

$$r_j = \frac{\$Net\ Profit_j}{Margin_j}. \tag{4}$$

[14]Cboe's Margin Manual can be found here: https://cdn.cboe.com/resources/membership/Margin_Manual.pdf.

Table 6: Margin-Adjusted Returns of Retail Trading in 0DTE Options

The table shows summary statistics of net-of-fees margin-adjusted returns (in %) of retail investor trades between February 2021 and September 2023, broken down by the trade's strategy. The identification of multi-leg strategies follows Li (2020). We show the frequency with which retail investors chose a particular strategy (Volume), the mean returns, as well as the 5th (P5), 25th (P25), 50th (Median), 75th (P75), and 95th (P95) quantiles of the return distribution.

Strategy	Volume (%)	Mean	P5	P25	Median	P75	P95
Put	34.2	-5.6	-100.0	-100.0	-0.7	0.6	182.0
Call	31.3	-9.4	-100.0	-100.0	-0.8	0.6	178.6
Put Spread	12.7	0.1	-100.0	-76.7	3.0	14.0	112.8
Call Spread	11.6	-0.2	-100.0	-65.3	3.3	16.5	110.5
Iron Condor	3.6	-1.1	-100.0	-24.0	5.5	15.4	63.9
Butterfly	3.2	-3.5	-100.0	-100.0	-7.2	14.8	228.8
Iron Butterfly	2.0	-0.9	-92.3	-28.8	-1.2	33.5	84.3
Condor	0.8	0.6	-100.0	-48.8	3.0	15.0	108.3
Strangle	0.3	-1.5	-100.0	-71.2	0.0	0.5	159.4
Straddle	0.3	-0.7	-87.7	-28.3	-0.1	2.1	105.5

The results for the ten most frequently used option strategies are shown in Table 6.

Consistent with the net profit results in Table 5, we find that the margin-adjusted returns of single-leg option trades are on average negative. The average put (call) losses amount 5.6% (9.4%) of the posted margin. The median is also negative but close to zero at -0.7% (-0.8%). We find that only 25% of trades generate returns of more than 0.6%. Given that we are talking about a holding period of less than a trading day, this could in theory lead to large annualized profits if an investor was able to consistently place bets that land among the 25% most profitable 0DTE trades. On the flip-side, more than 25% of retail trades that involve just put or call options expire worthless. The investor consequently loses 100% of the invested capital. The 5% most profitable put (call) trades generate huge returns of more than 182% (178.6%) of the posted margin, showcasing the positive skewness of returns of 0DTE options, which retail investors frequently favor (Bali et al., 2011; Boyer and Vorkink, 2014).

Turning to multi-leg strategies, we find that the median retail trade is profitable for both directional bets (Put and Call Spreads), as well as for some volatility strategies (Iron Condor, Condor). As for single-leg trades, we also find a skewed payoff profile for multi-leg strategies: while a large chunk of trades end up worthless or with severe losses, a handful of trades reap in profits that are multiples of the posted margin. Overall, strategies with a defined risk profile (Spreads, Condors, and Butterflies) tend to perform better than strategies where risks to the up- and/or the downside are unlimited (Strangles and Straddles, as well as naked short options).

4.2. What Makes Retail Trades (Un)Profitable?

Analogous to our analysis of the drivers of retail *demand*, we investigate drivers of retail *profitability* in two ways. First, we regress the aggregate daily retail dollar profits net of transaction costs (so using the recorded transaction prices, not mid-quotes at the time of the trade) on the same daily characteristics of the underlying index, including its realized variance, skewness, and price range, the total number of 0DTE contracts traded by retail investors, and a dummy indicating whether the FOMC announced a decision on that day. In Table 7, we find that daily retail profits are elevated on days with a more volatile underlying index, when the volatility of the index is measured by its realized price range, as the difference between the intraday high and low relative to the closing price. A one standard deviation increase in the price range corresponds to an increase in aggregate daily profits of $30,000. In contrast, realized variance, which is driving much of the overall decisions of retailers to trade 0DTE options in the first place shows no significant relationship with aggregate profits. We also find no significant relationship between realized skewness and aggregate retail profits, nor statistically different aggregate retail profits on FOMC announcement days. However, we find that days on which retailers are particularly active in the market for 0DTE options on the S&P 500, their aggregate profits drop substantially. A one standard deviation increase in the number of 0DTE contracts traded by retail investors is associated with lower aggregate profits of between

Table 7: Determinants of Aggregate Retail Profits

The table shows the results of regressing the daily net-of-fees profits of the aggregate retail trading activity in 0DTE options on the S&P 500 on various characteristics of the underlying S&P 500. RVar is the logarithm of the realized variance calculated using one-minute intraday returns, RSkew is the realized skewness as in Amaya et al. (2015) calculated using one-minute intraday returns of the S&P 500. Range denotes the difference between the realized intraday high and low prices of the S&P 500. Volume is the total number of 0DTE contracts traded by retail investors. FOMC is a dummy that equals 1 on FOMC announcement days. We standardize RVar, RSkew, Range and Volume, and include fixed effects for the day of the week in specification (6). The t-statistics are given in parentheses and are calculated using Newey and West (1987) standard errors with optimal lag length.

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.241	-0.241	-0.241	-0.241	-0.240	-0.230
	(-6.3)	(-6.3)	(-5.8)	(-6.6)	(-5.9)	(-3.8)
RVar	-0.037					
	(-1.0)					
RSkew		0.081			0.036	0.035
		(1.3)			(0.7)	(0.6)
Range			0.305		0.341	0.344
			(4.5)		(5.0)	(4.9)
Volume				-0.126	-0.197	-0.190
				(-3.3)	(-4.3)	(-4.0)
FOMC					-0.033	-0.116
					(-0.2)	(-0.5)
adj. R^2 (%)	-0.04	0.51	9.50	1.47	13.01	12.80
Day of Week FE	No	No	No	No	No	Yes

−\$13,000 and −\$20,000.

We next conduct a detailed trade-level analysis of the drivers of retail profits and losses in 0DTE options. For this, we regress each trade's margin-adjusted return on several trade-level characteristics. We also include day fixed effects. In the first specification of Table 8, we regress the trade-level margin-adjusted returns on moneyness (absolute Delta) and the trade's remaining hours to maturity. We find that trades with a larger absolute Delta tend to earn higher returns on average. On the contrary, trades with a shorter time to maturity tend to perform worse.

Adding the trade's expensiveness, which we measure with the average implied volatility of the contracts involved, uncovers a pronounced negative relationship with the trade's

Table 8: Trade-Level Drivers of Returns of Retail Trading in 0DTE Options

The table shows the results of regressing each retail trade's margin-adjusted net-of-fees return (in %) on several trade-specific characteristics. We include each trade's absolute Delta, time to maturity (TTM), average implied volatility, the number of contracts traded (Trade size), the average bid-ask spread at the time of entering the trade (BA Spread), the trade's directional exposure through Delta, and its risk profile through Gamma and Vega, as well as a Complex dummy that equals 1 if the trade involves multiple legs, a Debit dummy that equals 1 if the trade required an upfront payment to enter, and their interaction. We standardize non-dummy variables and include day fixed effects. Margin-adjusted returns are winsorized at the 1%-level. The t-statistics are given in parentheses and are calculated using standard errors clustered by day.

	(1)	(2)	(3)	(4)	(5)
|Delta|	0.095	0.087	0.087		0.110
	(35.76)	(33.09)	(33.07)		(38.83)
TTM	-0.023	-0.026	-0.026		-0.025
	(-1.97)	(-2.21)	(-2.17)		(-2.13)
IV		-0.163	-0.163		
		(-9.54)	(-9.56)		
Trade Size			0.009		
			(9.13)		
BA Spread			0.004		
			(3.09)		
Delta				0.000	
				(0.02)	
Gamma				-0.030	
				(-3.17)	
Vega				-0.052	
				(-2.82)	
Complex					0.079
					(7.98)
Debit					-0.287
					(-7.91)
Complex × Debit					0.160
					(8.64)
adj. R^2 (%)	8.89	9.29	9.30	8.60	10.43
Day FE	Yes	Yes	Yes	Yes	Yes

profitability: a one standard deviation increase in the trade's implied volatility is associated with a -16.3bps reduction in the trade's return. Table 3 has shown that retail traders favor long positions in option contracts with a high implied volatility. Combined with the results on the trade's profitability presented here, this suggests that retail traders' positioning in 0DTE options is poor, buying contracts that are particularly expensive to begin with, which ultimately results in lower average returns. In the third regression specification, we add two measures of the trader's conviction in the trade, in the form of the average bid-ask spread at the time of entering the trade, and the trade's size. Both measures of conviction are positively related to the net-of-fees margin-adjusted returns, suggesting that a retailer's strong conviction in the trade's design tends to turn out profitable. The impact is modest however, at an increase in the realized return of 0.9bps (0.4bps) per one standard deviation increase in the trade's size (bid-ask spread). Specification four investigates if retail traders are compensated for bearing greater risks through their options trades. Besides the trade's exposure to movements in the underlying index, we add the trade's Gamma and Vega as approximations for its exposure to jump and volatility risks (Dew-Becker, Giglio, and Kelly, 2021).

Finally, in specification five, we investigate if complex multi-leg trades outperform, and whether buying vs. selling the underlying contract or multi-leg strategy performs better on average. We include a Complex dummy that equals 1 if the trade involves multiple option legs, and a Debit dummy that equals 1 if the trade required an upfront payment to enter, which equates to being long the option in the case of single-leg trades, and being long the corresponding multi-leg strategy (like Straddles or Butterfly spreads). We also include their interaction to investigate if the average profitability of a long or short position in multi- vs. single-leg option positions differs. The coefficient of the Complex dummy informs us that the average margin-adjusted return of trades that involve multi-leg options strategies and that incur a credit today (the trader is short the complex strategy) is 7.9bps larger than the return of being short a single-leg position. Next, we find that single-leg positions that incur a credit today are substantially more profitable. Compared to long single-leg positions, short positions in individual options on average generate 28.7bps larger returns. Finally, the interaction between the Complex and the Debit dummies shows that going long multi-leg positions is significantly more profitable than going long single-leg positions, at 16bps for the average such trade.

We perform a similar analyses for different "clusters" of strategies followed by retailers in Appendix D, wherein we focus on single-leg trades, trades involving put and call spreads, and plays on volatility (straddles, strangles, (iron) condors and butterflies). A few regularities about the profitability of 0DTE retail trading emerge: trades with particularly expensive options leads to particularly poor performance, despite retailers' tendency to buy these options, and debit trades are significantly less profitable than credit trades.

5. Conclusion

Retail traders have a strong preference for high-risk, lottery-like assets (Bali et al., 2011; Bali, Brown, Murray, and Tang, 2017) and have found the perfect asset class to satisfy this demand in 0DTE options. These options expire within the same day and today represent more than 75% of all S&P 500 option trades by retail investors. Reddit and other websites promote 0DTE options as a simple method for generating quick profits. This paper provides evidence that 0DTE options are on average not a lucrative investment vehicle for retail traders.

The recent surge in retail options trading has been facilitated by exchange-related developments advocated by the Cboe and affiliated special interest groups to attract more retail interest in S&P 500 index options. We first confirm that Cboe's proposals have led to lower effective spreads for retail investors. We then show that the associated benefits only partially offset the high risks inherent in 0DTE options positions, which many retailers favor over options with longer maturities. Since the introduction of daily expirations, retail investors have incurred significant losses on their 0DTE trades, which amount to $-\$350{,}000$ per day, or a total of more than $-\$125$ million between February of 2021 and September of 2023. These numbers are conservative estimates as we disregard potential commissions paid to brokers, as well as regulatory and clearing fees.

We show that retail investors on average lose on single option positions, as well as on multi-leg positions that that are designed to limit the required margin to be posted, or allow for a dedicated bet on the volatility of the underlying index. At the same time, we can show that the bulk of multi-leg option trades are indeed profitable, and overshadowed by a few but very significant outliers. Aggregate retail profits from 0DTE options are elevated on days with a particularly active S&P 500 but decrease in their overall trading activity. At the level of individual trades, we find that much of the poor performance of retail traders is found in their decisions to buying particularly expensive option contracts, but that option strategies that involve multiple legs and trades in which the retailer shorts the corresponding contract or strategy perform significantly better.

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Appendix A. 0DTE on Reddit's WallStreetBets

Figure A1 shows the average number of comments on the "Daily Discussion" and "What Are Your Moves Tomorrow" threads on Reddit's r/wallstreetbets per month between January of 2017 and December of 2022, which mention either '0DTE' or '0 DTE'. Of course, 0DTE options are also frequently discussed in dedicated threads and several other subreddits. Many threads report impressive gains or severe losses.

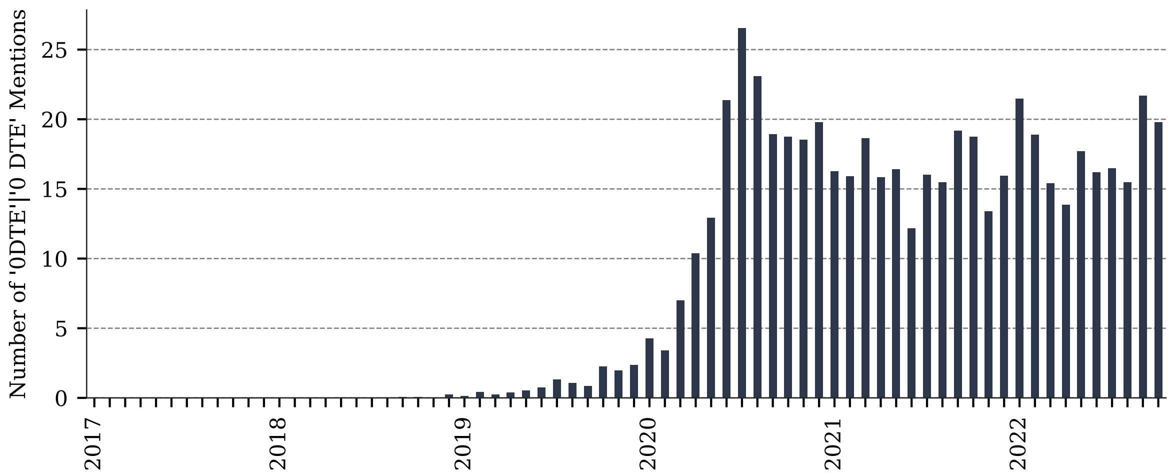

Fig. A1. Mentions of '0DTE' or '0 DTE' on Reddit's r/wallstreetbets

The figure shows the average number of comments on the "Daily Discussion" and "What Are Your Moves Tomorrow" threads on Reddit's r/wallstreetbets that mention '0DTE' or '0 DTE' between 2017 and 2022.

Appendix B. Alternative Identification of Retail Trades: Small Orders

Figure B2 shows the cumulative net-of-fees profits of retail trades, when we identify them using a simple heuristic based on the trade's size. All single-leg trades of size one are identified as "retail trades". Similarly, all multi-leg trades that involve a single instance of the 24 pre-specified option strategies (for example, buying one butterfly spread or selling one straddle) are also identified as "retail trades". The breakdown in Table 1 shows that while there is a considerable overlap between our preferred identification of retail trades using the transaction code found in our trade-level dataset and single-leg trades (74.2% of retail trades identified using the transaction codes SLAN or MLAT are of size one), more than half of the overall volume involves trades with a size greater than one and would thus not be identified with the heuristic of a trade size of one. At the same time, other market participants may also engage in trades of size one, conflating the "real" demand and profitability of retail investors in the market for 0DTE options on the S&P 500 and other market participants, such as hedge funds. Nonetheless, the results in Figure B2 show that net-of-fees profits using this alternative identification scheme follow a similar pattern as those reported in Figure 6 using the identification based on the transaction codes.

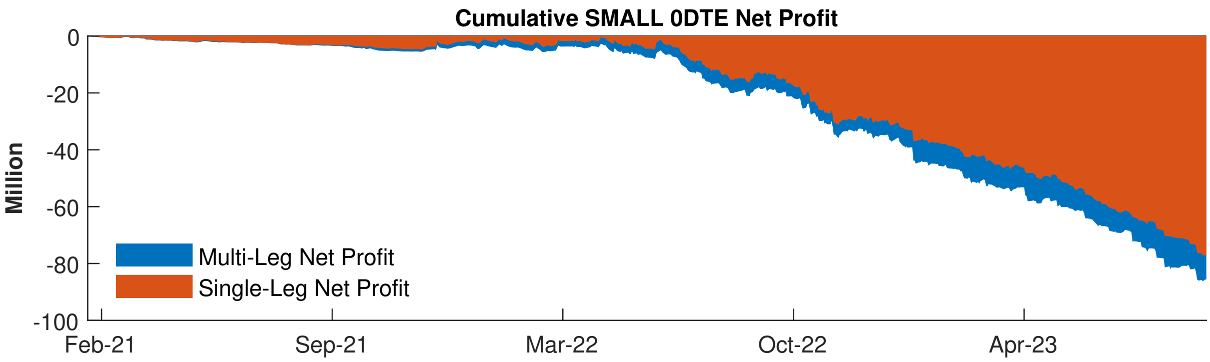

Fig. B2. Cumulative Daily Profits of Orders of Size One in 0DTE Options

The figure shows the cumulative daily net-of-fees profits of the aggregate "retail" trading activity in 0DTE options on the S&P 500 following the definition in Eq. (3) between February 2021 and September 2023. Here, retail trades are identified using a simple heuristic as trades of an order size of one.

Appendix C. Complex (Multi-leg) Option Strategies

Table C1 shows the volume and frequency share of the 24 complex option strategies that involve multiple legs, which we can identify for the retail trading activity in 0DTE options on the S&P 500. We can assign 97.99% of all trades and 98.24% of the entire retail volume to one of the 24 complex strategies.

Table C1: Complex Option Strategies Employed by Retail Traders

The table shows the volume and frequency share of the 24 pre-defined complex option strategies that involve multiple legs, which we can identify for the retail trading activity in 0DTE options on the S&P 500 options between Februray 2021 and September 2023.

Strategy	Volume Share (%)	Frequency Share (%)
Put Spread	36.87	34.51
Call Spread	33.67	31.22
Iron Condor	7.59	8.49
Butterfly	5.98	6.58
Iron Butterfly	4.30	6.42
Butterfly (Skip Strike)	2.15	2.34
Iron Condor (Skip Strike)	1.38	1.65
Condor	1.32	1.24
Iron Butterfly (Skip Strike)	0.77	1.27
Strangle	0.69	0.99
Straddle	0.65	1.07
Condor (Skip Strike)	0.45	0.43
Put Spread (Ratio)	0.44	0.29
Call Spread (Ratio)	0.39	0.29
Iron Condor (Other)	0.39	0.19
Butterfly (Other)	0.39	0.33
Condor (Other)	0.26	0.19
Condor (Ratio)	0.15	0.11
Iron Condor (Ratio)	0.12	0.09
Butterfly (Ratio)	0.10	0.07
Strangle (Ratio)	0.06	0.07
Iron Butterfly (Ratio)	0.06	0.08
Iron Butterfly (Other)	0.04	0.06
Straddle (Ratio)	0.02	0.02
Not Identified	1.76	2.01

Appendix D. Drivers of Retail Performance By Retail Strategy

The following tables replicate the investigation of the trade-level drivers of retail performance in 0DTE options (see Table 8) for different "clusters" of options: Table D2 for single-leg trades, Table D3 for put and call spreads, and Table D4 for trades involving volatility strategies, including straddles, strangles, and (iron) condors and butterfly spreads.

Table D2: Trade-Level Drivers of Returns of Retail Trading in Sinlge Leg 0DTE Options

The table shows the results of regressing the margin-adjusted net-of-fees return (in %) of retail trades involving a single option leg on several trade-specific characteristics. We include each trade's absolute Delta, time to maturity (TTM), average implied volatility, the number of contracts traded (Trade size), the average bid-ask spread at the time of entering the trade (BA Spread), the trade's directional exposure through Delta, and its risk profile through Gamma and Vega, as well as a Complex dummy that equals 1 if the trade involves multiple legs, a Debit dummy that equals 1 if the trade required an upfront payment to enter, and their interaction. We standardize non-dummy variables and include day fixed effects. Margin-adjusted returns are winsorized at the 1%-level. The t-statistics are given in parentheses and are calculated using standard errors clustered by day.

	(1)	(2)	(3)	(4)	(5)
|Delta|	0.117	0.108	0.108		0.114
	(34.27)	(30.56)	(30.56)		(34.44)
TTM	-0.037	-0.035	-0.035		-0.037
	(-2.48)	(-2.40)	(-2.41)		(-2.50)
Call	-0.013	-0.045	-0.045		-0.010
	(-0.26)	(-0.89)	(-0.89)		(-0.20)
IV		-0.196	-0.196		
		(-8.21)	(-8.21)		
Trade Size			0.002		
			(2.39)		
BA Spread			-0.003		
			(-1.21)		
Delta				0.000	
				(0.01)	
Gamma				-0.032	
				(-3.09)	
Vega				-0.051	
				(-2.62)	
Debit					-0.280
					(-7.54)
adj. R^2 (%)	10.59	11.10	11.10	10.01	11.85
Day FE	Yes	Yes	Yes	Yes	Yes

Table D3: Trade-Level Drivers of Returns of Retail Trading in 0DTE Vertical Spreads

The table shows the results of regressing the margin-adjusted net-of-fees return (in %) of retail trades involving put and call spreads on several trade-specific characteristics. We include each trade's absolute Delta, time to maturity (TTM), average implied volatility, the number of contracts traded (Trade size), the average bid-ask spread at the time of entering the trade (BA Spread), the trade's directional exposure through Delta, and its risk profile through Gamma and Vega, as well as a Complex dummy that equals 1 if the trade involves multiple legs, a Debit dummy that equals 1 if the trade required an upfront payment to enter, and their interaction. We standardize non-dummy variables and include day fixed effects. Margin-adjusted returns are winsorized at the 1%-level. The t-statistics are given in parentheses and are calculated using standard errors clustered by day.

	(1)	(2)	(3)	(4)
|Delta|	0.040	0.036	0.025	0.049
	(12.71)	(11.79)	(6.62)	(20.71)
TTM	0.022	0.012	0.010	0.015
	(7.05)	(3.75)	(3.14)	(4.88)
IV		-0.058	-0.047	
		(-10.02)	(-7.74)	
Trade Size			-0.000	
			(-0.38)	
BA Spread			-0.047	
			(-4.82)	
Debit				-0.154
				(-5.36)
adjusted R^2	2.23	2.33	2.59	2.91
Day FE	Yes	Yes	Yes	Yes

Table D4: Trade-Level Drivers of Returns of Retail Trading in 0DTE Volatility Strategies

The table shows the results of regressing the margin-adjusted net-of-fees return (in %) of retail trades involving volatility-based strategies (straddles, strangles, (iron) condors and butterflies) on several trade-specific characteristics. We include each trade's absolute Delta, time to maturity (TTM), average implied volatility, the number of contracts traded (Trade size), the average bid-ask spread at the time of entering the trade (BA Spread), the trade's directional exposure through Delta, and its risk profile through Gamma and Vega, as well as a Complex dummy that equals 1 if the trade involves multiple legs, a Debit dummy that equals 1 if the trade required an upfront payment to enter, and their interaction. We standardize non-dummy variables and include day fixed effects. Margin-adjusted returns are winsorized at the 1%-level. The t-statistics are given in parentheses and are calculated using standard errors clustered by day.

	(1)	(2)	(3)	(4)
|Delta|	0.023	0.023	0.020	0.033
	(4.63)	(4.58)	(4.05)	(7.50)
TTM	0.006	0.002	0.002	-0.000
	(1.57)	(0.57)	(0.40)	(-0.01)
IV		-0.027	-0.013	
		(-4.07)	(-1.87)	
Trade Size			-0.004	
			(-1.73)	
BA Spread			-0.039	
			(-9.78)	
Debit				-0.127
				(-6.33
adjusted R^2	1.09	1.11	1.31	1.63
Day FE	Yes	Yes	Yes	Yes