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

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Abstract

Our study investigates the implications of trading in options that expire on the same day – so-called "0DTE" options – through the lens of retail investors. Almost the entire growth of trading in S&P 500 index options can be traced back to demand for 0DTE options. We use recent exchange-related developments to identify option trades that originate from retail investors, and find that more than 75% of their trades in S&P 500 options today are in 0DTE contracts. While retail investors benefit from significant price improvements in the form of lower effective spreads, they experience large losses on average: between February 2021 and September 2023, retail investors lost $241,000 on an average day; since the introduction of a daily expiration calendar in May of 2022, this number has grown to average losses of $350,000 per day. We find that single-leg trades, trades that require an upfront payment to be set up, and trades that use high-implied volatility options are responsible for these losses. In contrast, multi-leg trades and trades that capture the compensation for volatility and jump risks are significantly more profitable.

Keywords: Retail Trading, Options, WallStreetBets, Payment for Order Flow, 0DTE

JEL classification: G4, G5, G12, D4

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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 are appealing 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. In a recent Forbes article, Vineer Bhansali asked ChatGPT for its opinion on the dangers of 0DTE options. Here's what the AI had to say: "The danger with 0DTE options is that the price of the underlying asset can move quickly and unpredictably, especially on the day of expiration. This can result in significant gains or losses, depending on the direction of the price movement."[2] Financial professionals also expressed their concerns about the substantial growth in 0DTE options trading. Quoting a white paper by J.P. Morgan, Reuters reports that 0DTE options might contribute to market fragility and have the potential to amplify market downturns, potentially turning a "5% intraday market decline into a 25% rout".[3] We show that almost the entire growth in S&P 500 options trading over the last few years can be attributed to these ultra-short-term contracts.

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 (Boulatov, Eisdorfer, Goyal, and Zhdanov, 2022). Furthermore, on July 9, 2020, the Securities Industry and Financial Markets Association ("SIFMA") issued a letter to

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

[2] https://www.forbes.com/sites/vineerbhansali/2023/03/03/gamma-mama-could-0dte-options-be-the-cause-of-the-next-market-meltdown/?sh=53c647b61a77.

[3] https://www.reuters.com/markets/us/0dte-options-could-turn-5-intraday-market-decline-into-25-rout-jpmorgan-2023-03-06/.

the Cboe supporting the changes in proposal SR-CBOE-2020-051 to encourage greater retail participation in S&P 500 index options. The Cboe was proposing to activate its Automated Price Improvement Mechanism (AIM) 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 in SPX options".[4] 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. The Cboe also notes that smaller order sizes are favored by market makers who take the opposite side of the trades. Smaller orders are easier to hedge, "which may encourage Market-Makers to compete to provide price improvement in an electronic competitive auction process."

This paper investigates if retail investors have benefited from trading 0DTE options.

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. We start our analysis by providing a number of stylized facts about 0DTE trading. Since February of 2021 we can identify retail trades in S&P 500 options through transaction codes "SLAN" – short for "Single Leg Auction Non ISO" – and "MLAT" – "Multi-leg Auction". Other studies that rely on the identification of retail trades through the price improvement mechanism have typically focused exclusively on single-leg trades in the equity option market (Bryzgalova, Pavlova, and Sikorskaya, 2023; Ernst and Spatt, 2022). To provide a comprehensive overview of the trading activity of retail investors in S&P 500 options between January 2021 and September 2023, we also include their use of multi-leg trades. Complex option strategies are typically employed to reduce the required margin requirements 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, 2023a,b). We follow Li (2020) to identify the complex options strategies pursued by retail investors.

We first show that 0DTE options are responsible for most of the overall growth in the trading activity of S&P 500 options. Today, more than 40% of all traded contracts expire on the same day and most positions in these ultra-short-term options are closed before maturity. Second, end consumers buy more 0DTE options than they sell. This in turn

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

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 in recent months.

As a third stylized fact, we 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. Fourth, 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. Fifth, 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.

Sixth, the proposed price improvement discussed in Cboe proposal SR-CBOE-2020-051 works: effective spreads for retail orders are smaller than for the remaining 0DTE trades. Overall, we find that retail investors favor small order sizes, with 72% of all orders trading a single option. Apart from differences in the order size, we find few systematic differences between retail and non-retail trading in 0DTE options. The two trader groups buy and sell options with roughly equal frequency, slightly favor puts over calls, and focus on at-the-money and slightly out-of-the-money 0DTE options with 3–24 hours to maturity. Finally, "0DTE" is a popular topic in discussions on Reddit's r/wallstreetbets. Since mid-2020, it is mentioned in over 20 comments per day on the "Daily Discussion" and "What Are Your Moves Tomorrow" threads.

We next investigate if the popularity of 0DTE options by retail investors is founded in the aggregate performance of their 0DTE investments. The answer is a resounding "No": across our sample period spanning almost three years, retail investors together lost more than $125 million. More than $90 million of these losses are the result of the transaction costs, the remainder a result of poor positioning. Cumulative losses gross-of-fees have remained relatively constant since November of 2022, whereas the losses driven by transaction costs continue to grow. Despite Cboe's price improvement mechanism, transaction costs for 0DTE options remain particularly high and drive the aggregate 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 the former. Retail investors lost more than $100 million in their single-leg option positions. 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 net 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 have grown to $350,000. Roughly 60% of daily losses are the result of transaction costs, 60% are driven by investments in 0DTE put options, 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.

We next conduct a detailed analysis of the drivers of retail profits and losses in 0DTE options. For this, we regress each trade's margin-adjusted return on the trade's total Delta, Gamma, and Vega. Delta represents the trade's total directional exposure, while Gamma and Vega are rough proxies for the trade's exposure to jump and volatility risks, respectively (Dew-Becker, Giglio, and Kelly, 2021). Retail investors are on average compensated for taking on riskier positions. A one standard deviation increase in Gamma (Vega) generates larger returns of 0.019% to 0.045% (0.018% to 0.094%) over the remainder of the trading day, depending on the panel regression's specification. We also add each trade's average implied volatility (IV) as a measure of expensiveness: retail trades are particularly poor in high-IV contracts and in high-IV times. Finally, we generate corroborating evidence that complex trades generate significantly larger return. Multi-leg positions on average net a larger return of 0.17% compared to single-leg positions. Positions that require an upfront payment to be set up on average generate significantly negative returns, which reflects the average additional compensation for the option seller.

Since January of 2022, we find that the overall level of expensiveness of 0DTE options has increased drastically. We measure the expensiveness using the Cboe's VIX formula on all option trades between 9:30 and 9:40. We provide indicative evidence that retail investors in the aggregate have learned to take the overall expensiveness of 0DTE op-

tions into account. While their net profits are significantly negatively related to the level of 0DTE option expensiveness over the full sample, in line with greater losses whenever 0DTE options were particularly expensive, we find no such relationship after the introduction of daily expirations in May of 2022.

Related Literature

Our paper adds to a growing literature analyzing the behavior of retail investors. 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 (2022b) 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. Barber, Lin, and Odean (2022) reconcile the seemingly conflicting evidence on the performance of retail trading activity. Our results add to this debate by focusing on ultra-short-term S&P 500 index options. We show that a) retail investors consider information about the overall expensiveness of 0DTE options in their trade positioning, and b) that their aggregate losses are primarily driven by paying hefty transaction fees.

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). 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 (2022a) 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. We add to these studies by focusing on the recent trend of trading options that expire on the same day. 0DTE options are particularly popular among retail investors and today represent the bulk of retail trading in S&P 500 options. While these options are a way to satisfy the demand for lottery-like payoffs (Bali et al., 2011; Filippou et al., 2018), retail investors pay a hefty premium to participate, especially in the form of high transaction costs.

Only a handful of studies have so far looked at this new 0DTE options market. Brogaard, Han, and Won (2023) show that 0DTE trading impacts the volatility of the S&P 500 index and Bandi, Fusari, and Renò (2023) introduce a pricing model for 0DTE options. Vilkov (2023) studies the on-paper profitability of static option strategies, which involve 0DTE options. Finally, Londono and Samadi (2023) use 0DTE options to investigate the pricing of uncertainty around economic release dates. 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 is one step in that direction.

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 January 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 *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.

Finally, we have obtained data on the signed trading volume for each option×day. This Open/Close dataset provides a breakdown of who initiated a trade and whether the trade established a new position or closed an existing one. Option trades for each contract are categorized as either open buy, open sell, close buy, or close sell. Each category is further broken down into different types of market participants: *customers*, *professional customers*, *broker-dealers*, *firms*, and *market makers*.

3. The 0DTE Options Landscape

To provide insight into the rising popularity of 0DTE options, we show the monthly trading volume in S&P 500 options for our sample period from January 2005 to September 2023 in Panel A of Figure 1. We separate the transacted volume in 0DTE options from the volume in all other maturities. While 0DTE options have played a small role until 2018, they have since rapidly risen in popularity. Over the last five years, they represent most of the overall growth in S&P 500 options trading.

Panel B of Figure 1 corroborates this finding. It shows the monthly trading volume since 2018. The entire growth in index options trading is amassed in short-term options with maturities of up to four days. The bulk of this increase is 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 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 always have access to ultra-short-term 0DTE options.

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 stands at more than 60%. Of this 60%, more than two thirds are found in 0DTE options

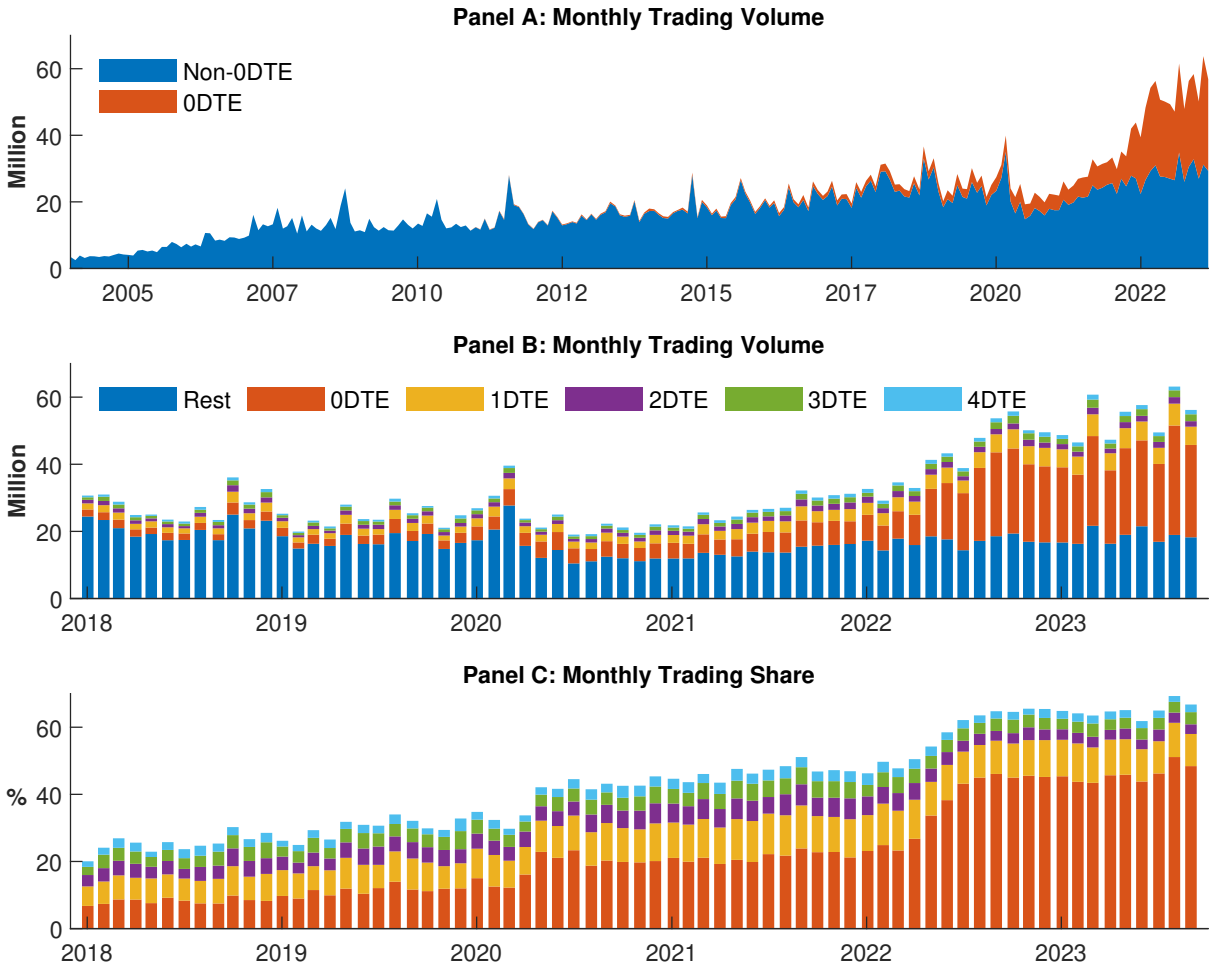

Fig. 1. Trading in S&P 500 options

The figure shows the monthly trading volume and trading share in S&P 500 options across different option maturities. Panel A plots the the monthly trading volume from January 2004 until September 2023. Panel B shows the monthly trading volume from January 2018 until September 2023. Panel C plots the monthly trading share from January 2018 until September 2023

which have seen the largest increase in demand. Overall, there is a considerable demand for short-term and ultra-short term options exposure.

Moreover, we investigate who provides liquidity in this rapidly expanding market and warehouses the associated risks of selling 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. Accordingly, we provide a breakdown of the overall order imbalance of the aggregate option market maker over time in Figure 2. We use the Open/Close profile described in Section 2, which identifies

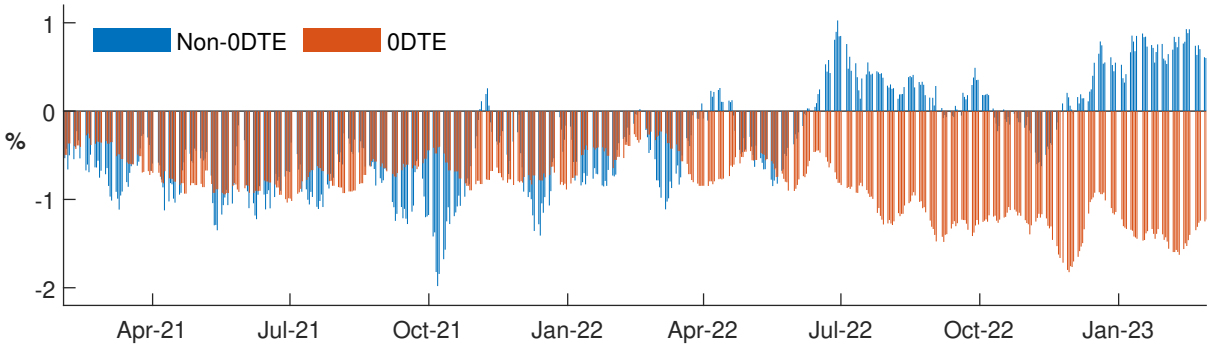

Fig. 2. 5-day moving average market maker order imbalance

The figure shows the daily 5-day moving average market maker order imbalance in S&P 500 0DTE and non-0DTE options from February 2021 until September 2023. The market maker order imbalance is defined as the number of contracts bought minus the number of contracts sold by the market makers (see eq. (1)). The respective daily order imbalance of 0DTE and non-0DTE options is scaled by the daily total number of S&P 500 options traded.

options trades that involve the market maker. The relative order imbalance is defined as:

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

for the ith option series. 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 then consistently dipped below -1%. End consumers have net-long demand for these options. Market makers consequently absorb this demand and hold a large short position in 0DTE options. In the introduction we have referred to a market commentary by J.P. Morgan, warning of the potential dangers of 0DTE trading. Option market makers have negative Gamma exposure, as a result of their large and negative order imbalance in 0DTE options. To rebalance their hedges, they therefore need to invest in the same direction as the previous market move, which potentially increases the magnitude of intraday market swings. Ni, Pearson, Poteshman, and White (2021) and Barbon, Beckmeyer, Buraschi, and Moerke (2022) study the broader implications of the hedging activity of option market makers on the volatility and prices of the underlying stocks. Gayda, Grünthaler, and Harren (2022) show that option market makers try to manage their Gamma exposure by

encouraging changes in end consumer demand.

Comparing the market maker's order imbalance in 0DTE options with the imbalance in the remaining maturities, we find that it is also predominantly negative in the remaining maturities before the introduction of a daily expiration cycle in May of 2022. Afterwards, we find that the order imbalance tends to be positive, suggesting that option market makers facilitate the demand for shorting options of end consumers and consequently build up a long position in non-0DTE options.

3.1. 0DTE and Retail Investors

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".

The implementation of the proposed changes allows us to identify retail trades. Trades 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 are listed with OPRA type descriptions SLAN, short for *Single Leg Auction Non Iso*, or MLAT, short for *Multi Leg Auction* in case where a single order involved multiple option legs. Multi-leg option trades offer several advantages compared to "naked" option positions. Key among these benefits is a more defined risk profile, which typically results in lower margin requirements. Since margin requirements for retail investors are typically calculated following Regulation T, naked option positions often times bind considerable capital. Furthermore, Li et al. (2023a) 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 for example allow investors to bet on the volatility of the underlying. Using these development, we can identify the majority of retail trading in S&P 500 index options since February, 22 of 2021, and differentiate between single- and multi-leg trades. 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. We complement single-leg evidence with results from complex option strategies. Hu, Kirilova, Park, and Ryu (2023) show for the Korean options market that retail investors that favor complex strategies make more profitable investment decisions. We investigate if this source of investor heterogeneity also shows up in the U.S. index options market.

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. We can identify retail trades between January of 2021 and September of 2023. During this period, retail trading in S&P 500 options has grown steadily, from roughly half a million contracts per month for the first half of 2021 up to a million contracts for 2021's second half and the first quarter of 2022. Since May of 2022 the growth in retail volume has picked up even more, which coincides with the introduction of Tuesday and Thursday expirations for S&P 500 options. 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 in a 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.

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. Nonetheless, the graph shows that it is vital to not only consider single-leg trades

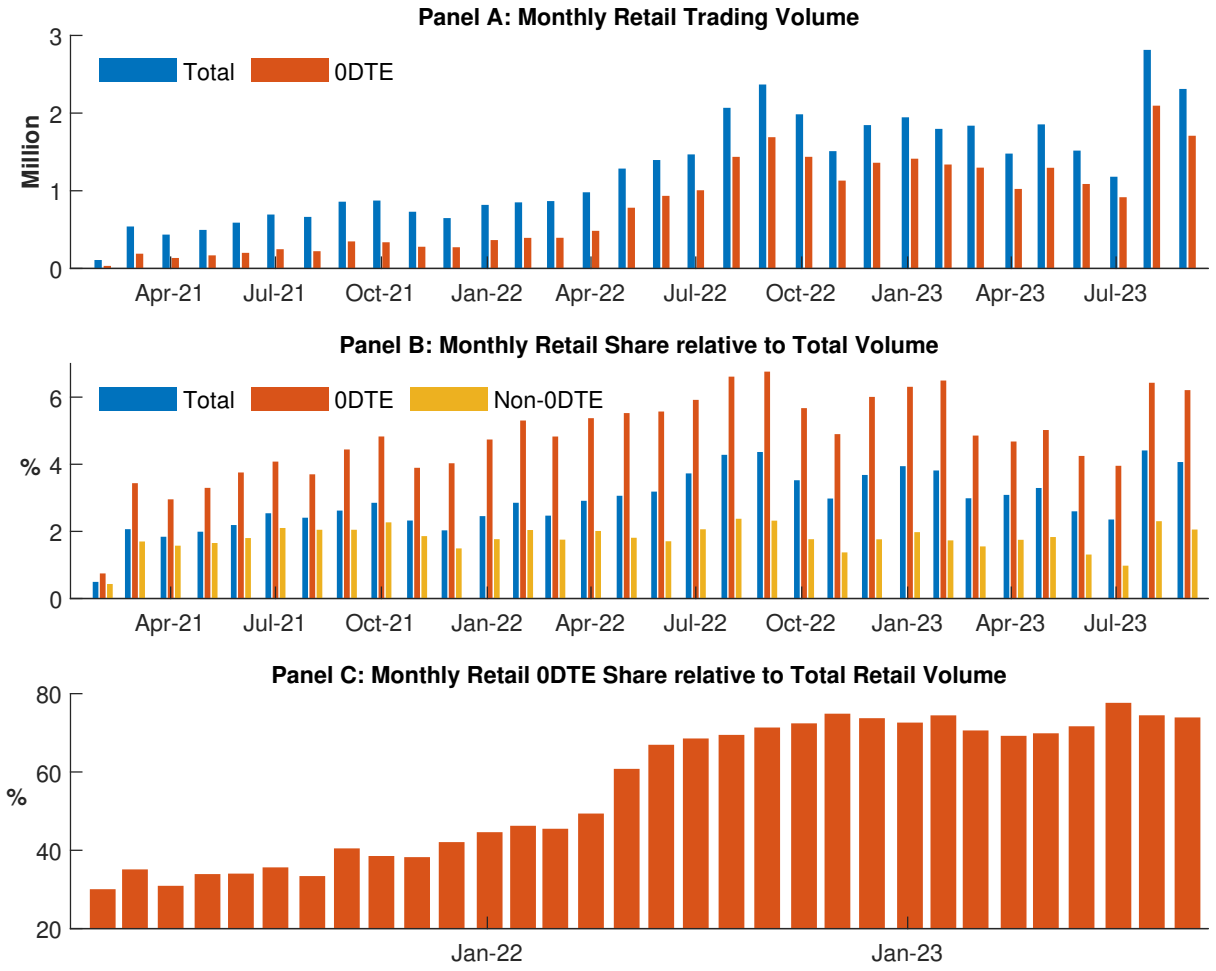

Fig. 3. Retail options volume

This figure shows the monthly retail trading volume and share in SPX options from February 2021 until September 2023. Panel A shows the monthly retail trading volume for all SPX options and 0DTE SPX options. Panel B shows the monthly retail share of the trading volume for all SPX options, 0DTE SPX options and non-0DTE SPX options. Panel C shows the monthly retail trading volume in 0DTE SPX options relative to the monthly retail trading volume in all SPX options.

but also retail investment decisions that rely on multi-leg positions. To identify which strategies are 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. 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-

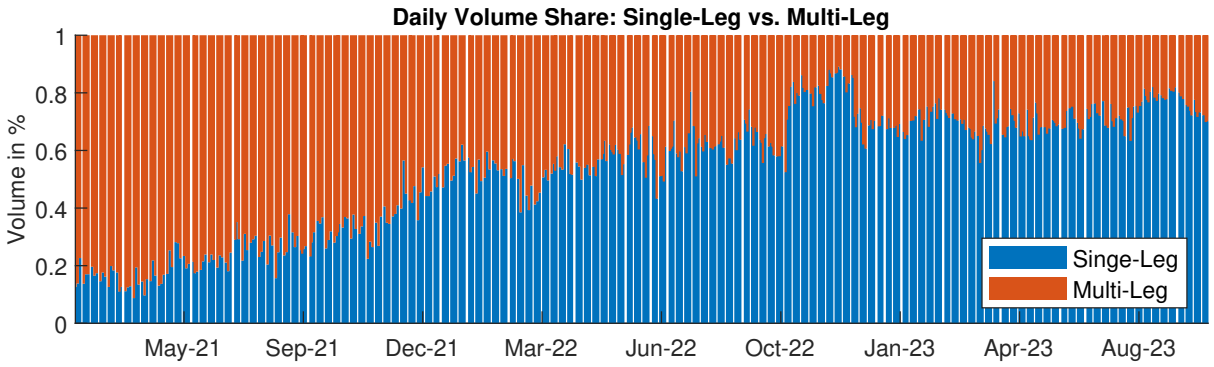

Fig. 4. Retail options volume

This figure shows the relative share of single-leg vs. multi-leg trades in 0DTE options, which originate from retail investors from February 2021 until September 2023.

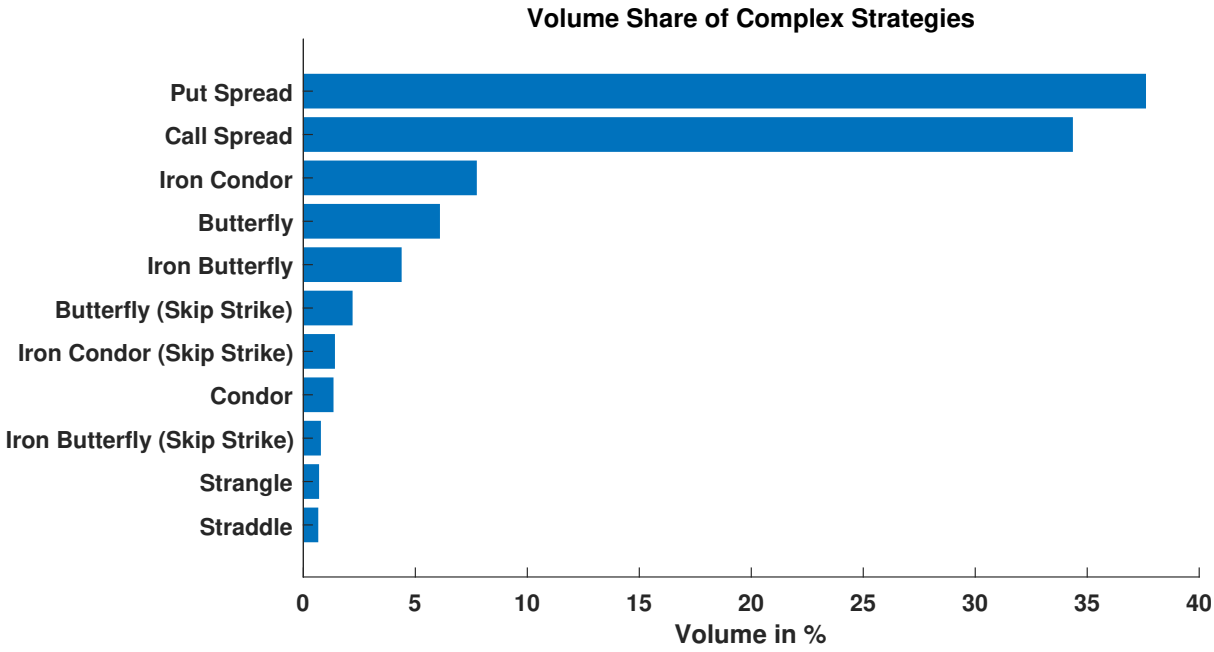

Fig. 5. Complex Strategies

This figure shows the volume share of the top 11 complex (multi-leg) option strategies used by retail investors between February 2021 and September 2023.

vs. downside volatility. We find that Put and Call Spreads are the dominant multi-leg strategy and represent roughly 70% of all 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 frequently used by

retail investors. (Iron) Condors and Butterflies all feature a predefined risk exposure and lowered margin requirements, which are two characteristics apparently favored by retail investors. Strangles and Straddles, with undefined up- or downside exposure, in contrast are seldom used.

Given the massive interest of retail investors, a careful consideration of the drawbacks and benefits posed by 0DTE options is therefore not only in the interest of the retail investor community but also in the interest of financial regulators.

We next take a closer look at the trading decisions in 0TE options for retail investors and non-retail investors. We investigate whether the two investor groups differ systematically in their contract choice, chosen holding period and trade direction. Table 1 shows the average quoted and effective spreads, 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 time-to-maturity and moneyness.

We first confirm that the proposed price improvement mechanism works. For this, we define the quoted and effective spread of trade j as:

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

To make single- and multi-leg trades comparable, we consider the average spread of the contracts included in the complex strategy. 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 quoted *and* effective spreads, compared to trades that originate from non-retail investors. On average, they pay an effective spread of 6.0% for calls and 5.0% for puts, compared to 12.5% and 9.6% – a considerable improvement of roughly 50%.

The largest difference in the trading activity of retail and non-retail investors is in the trade size: retailers favor small order sizes, with 74.2% of all orders trading a single option. 23.5% trade between 2 and 5 options, only 2.2% between 6 and 10, and naturally no retail orders trade more than 10 contracts. The retail identification procedure only allows us to identify retail trades of order sizes up to 10 contracts, which fall under the price improvement mechanism. While non-retail investors also favor small order sizes, they occasionally trade in larger quantities, such that more than a third of their volume is transacted through orders of 11 or more contracts.

Table 1: Retail vs. Non-Retail trading in 0DTE options

The table shows the daily average characteristics of retail and non-retail 0DTE trades. The sample covers the period from February 2021 until September 2023. The quoted and effective spreads are measured as in 2. Trades are classified as buy, sell and mid according to the quote rule following Muravyev (2016). Moneyness is defined as $\log(K/S)$ at the time of the trade.

		0DTE Retail				**0DTE Non-Retail**			
Characteristic	Category	Freq. (%)	Volume (%)	QS (%)	ES (%)	Freq. (%)	Volume (%)	QS (%)	ES (%)
Type	Call	48.5	48.7	11.8	6.0	49.4	48.9	20.4	12.5
	Put	51.5	51.3	10.5	5.0	50.6	51.1	17.6	9.6
Size	1	74.2	47.4	10.5	5.4	55.3	16.8	17.0	10.0
	2-5	23.5	40.8	12.4	5.7	30.1	26.6	20.3	11.7
	6-10	2.2	11.4	16.2	7.4	8.7	20.9	21.9	12.4
	11 - 100	0.0	0.4	21.1	8.7	5.8	34.6	24.6	14.9
	Above 100	0.0	0.0	0.0	0.0	0.1	1.0	54.9	18.4
Direction	Buy	39.9	38.2	12.0	8.4	38.4	38.2	24.8	20.5
	Sell	42.3	42.4	10.3	5.2	45.3	45.6	14.1	6.9
	Mid	17.8	19.4	11.0	0.0	16.3	16.2	18.2	0.0
Direction: Call	Buy	19.5	18.8	13.4	9.8	19.5	19.1	28.3	23.8
	Sell	20.3	20.5	10.6	5.2	22.1	22.0	14.3	7.0
	Mid	8.7	9.4	11.5	0.0	7.8	7.7	18.2	0.0
Direction: Put	Buy	20.4	19.4	10.6	7.1	18.9	19.0	21.5	17.4
	Sell	21.9	21.9	10.1	5.2	23.2	23.6	14.1	6.9
	Mid	9.1	10.0	10.8	0.0	8.4	8.5	18.4	0.0
TTM	1 hour	11.3	12.2	19.0	10.5	15.4	16.0	31.0	21.1
	1-3 hours	24.1	24.3	11.4	5.9	24.0	24.1	19.3	11.4
	3-24 hours	64.6	63.4	9.6	4.5	60.5	59.9	15.6	8.4
Moneyness: Call	Below -2%	0.0	0.0	2.2	0.2	0.0	0.0	2.4	0.4
	-0.5% to -2%	0.9	0.9	2.6	0.4	0.9	0.9	2.9	0.7
	At The Money	30.2	29.9	6.2	3.0	27.2	25.4	8.7	4.9
	0.5% to 2%	16.1	16.4	24.5	12.8	19.0	19.7	36.6	22.7
	Above 2%	1.3	1.4	98.2	80.2	2.3	2.9	97.7	83.5
Moneyness: Put	Below -2%	3.0	3.2	70.5	44.6	4.7	5.7	89.3	62.5
	-0.5% to -2%	19.3	19.2	14.5	7.0	21.2	21.9	20.6	10.5
	At The Money	28.4	28.1	5.7	2.7	23.9	22.6	7.9	4.3
	0.5% to 2%	0.8	0.8	3.0	0.5	0.8	0.8	3.3	0.8
	Above 2%	0.0	0.0	2.7	0.3	0.0	0.0	3.1	0.5

On average, the trade direction of retail and non-retail orders are comparable: we identify 39.9% (42.3%) of retail trades as buys (sells), and 38.4% (45.3%) of non-retail trades as buys (sells). The remaining trades are executed at the prevailing mid-quote. We further separate the average trade direction by puts and calls and find similar numbers for both. In contrast to Bryzgalova et al. (2023) who document a clear preference of retail investors for call options, we find a very slight preference for put options, which importantly does not differ substantially from a preference for put options of non-retail investors. Finally, we document that 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.

Retail investors tend to enter 0DTE options positions in the first half of the trading day. 64.6% of their trades and 63.4% of their total volume is executed with 3–24 hours until the option expires. The numbers for non-retail investors are comparable at 60.5% and 59.9%. Daily expirations are settled at 4pm Eastern time. Non-retail investors trade a larger fraction in options with at most one hour left to expiration. About 15.4% of their trades are in these maturities, compared to 11.3% for retail investors. Interestingly, retail investors also 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. Furthermore, retail traders heavily favor at-the-money contracts, and contracts slightly out-of-the-money. These options represent more than 90% of their transacted volume.

0DTE on r/wallstreetbets. 0DTE options are a frequent discussion point by retail investors on Reddit's r/wallstreetbets.[5] In Figure 6 we plot the average number of daily mentions of either '0DTE' or '0 DTE' in the comment sections of the "Daily Discussion" and "What Are Your Moves Tomorrow" threads. The two threads are where most discussions on r/wallstreetbets take place. Nonetheless, a simple search reveals that many individual threads exist that focus on the 0DTE topic. The number of mentions we show here is therefore a lower bound on the topic's overall discussion intensity.

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 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.

[5] 0DTE options are also frequently discussed in other Subreddits, for example in r/Dayrading, r/thetagang, or r/options.

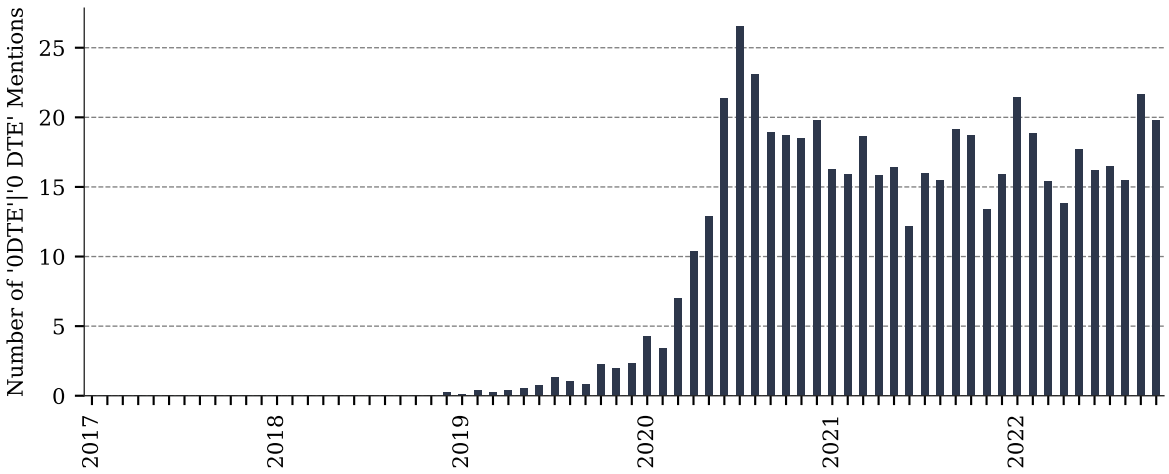

Fig. 6. Mentions of '0DTE' and '0 DTE' on Reddit's r/wallstreetbets

The figure shows the average number of comments on the "Daily Discussion" and "What Are Your Moves Tomorrow" threads on Reddit's r/wallstreetbets. We show the average number of mentions per month between 2017 and 2022.

4. Profitability of 0DTE SLIM 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 multi-leg positions. Finally, we investigate which characteristics lead to profitable trades, and show that retail investors have learned to incorporate the overall expensiveness of 0DTE options in their trade positioning.

4.1. Retail Investors Lose Money On 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

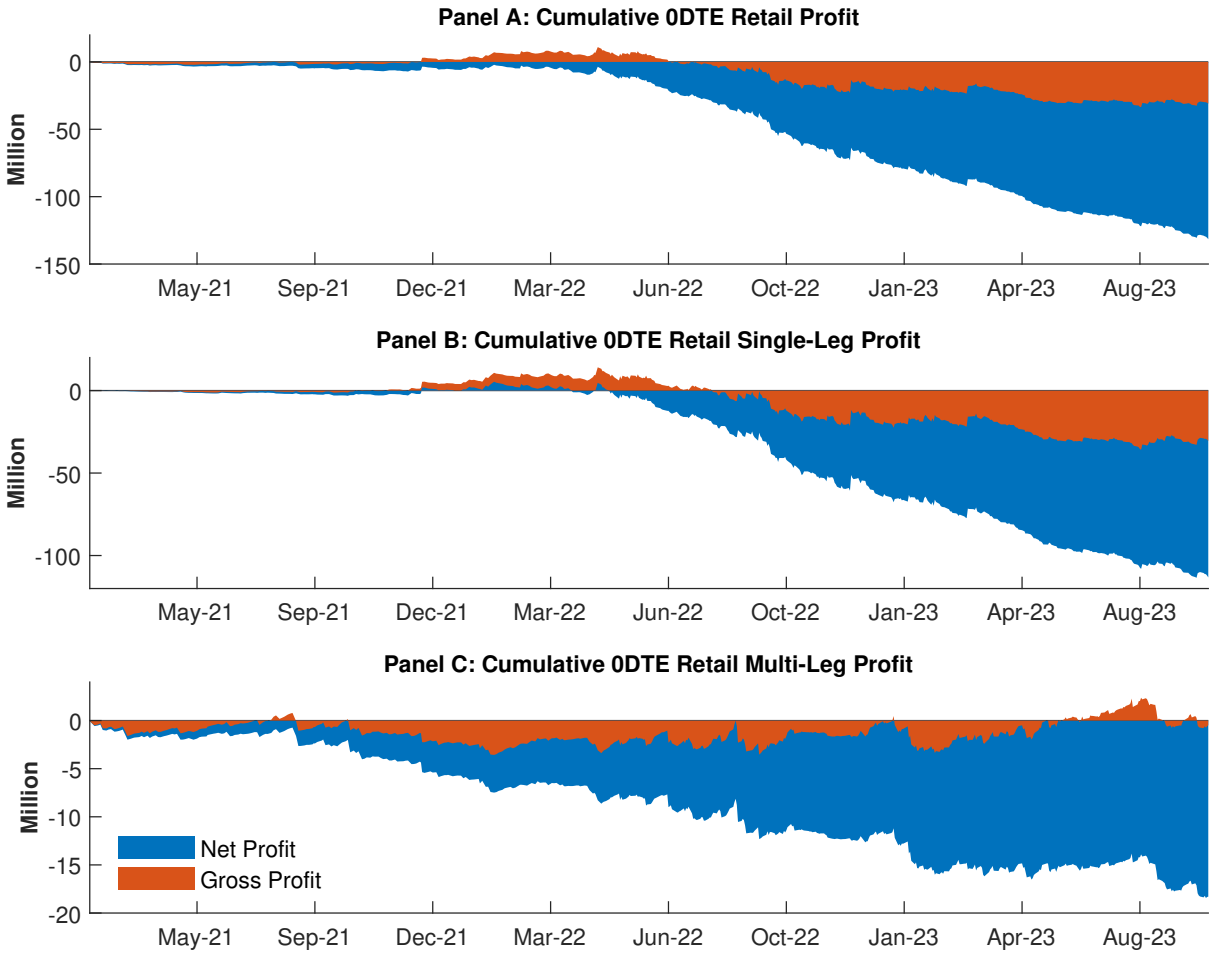

Fig. 7. Cumulative daily net and gross profits of 0DTE retail options

The figure shows the daily cumulative net and gross profit following Eq. (3) in 0DTE retail options from February 2021 until September 2023. Panel A shows the overall profits of retail investors, Panel B their profits in single-leg positions, and Panel C in multi-leg positions.

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. For the 18% of retail trades that occur at the mid-quote (see Table 1), the gross and net profits will naturally be the same.

We show the cumulative net and gross profits in Panel A of Figure 7. 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 USD at the end of our sample. Profits net-of-fees performed much worse and exceed −125 million USD by September 2023. Whereas cumulative gross profits remain flat after November 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.[6] Non-discount brokers, like Interactive Brokers, continue to charge commissions per contract, with a minimum of $1 USD per order. In a simple back-of-the-envelope calculation, this circumstance 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 7, 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 2. 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 7, 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

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

Table 2: Average daily net and gross profits in 0DTE retail options

The table shows the daily average net and gross profits as in equation 3 for all 0DTE retail options and 0DTE retail calls, puts and options that are classified as buy and sell according to the quote rule following Muravyev (2016). 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 of continuous offering of 0DTE options 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.

	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

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. 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 favour 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. Interestingly, whereas selling options tends to be more profitable in the average month, we find that retailers' buying activity netted positive profits after fees on the average Thursday. The cumulative profits, however, are insufficient to balance out the losses reaped in on the remaining days. These figures confirm that transaction costs are detrimental for the aggregate retail performance in 0DTE options. 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 selected strike from complex orders with multiple legs. Hu et al. (2023) show for the Korean market that more informed investors tend to favor complex option trades. In Table 3, 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 but the

distribution of net profits is fairly wide. 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 75th percentile also exceeds 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 average trade (Median) of many strategies is indeed profitable. Average profits instead are mostly negative, driven by a few negative outliers.

Table 3: Net Profits of 0DTE Retail Option Trades

The table shows summary statistics of the net 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.

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 strategy's 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.[7] From that, we calculate a trade's margin-adjusted returns as:

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

The results for the ten most frequently used option strategies are shown in Table 4.

Consistent with the net profit results in Table 3, 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%.

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

Table 4: Margin-adjusted Returns of 0DTE Retail Option Trades

The table shows summary statistics of the 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 net profits in dollars, as well as the 5th (P5), 25th (P25), 50th (Median), 75th (P75), and 95th (P95) quantile.

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

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 undefined (Strangles and Straddles, as well as naked short options).

4.2. What Makes Retail Trades (Un)Profitable?

We now perform a systematic analysis of the drivers of success and failure of retail trades in the market for S&P 500 options that expire on the same day. For this, we regress the margin adjusted net return of each position (Eq. 4) on several trade-specific indicators.

Table 5: Drivers of 0DTE Retail Returns

The table depicts the the regression of the margin adjusted net return as in Eq. (4) of 0DTE retail trades and specific trade characteristics. The *Complex* dummy equals 1 if the trades constitutes of multiple legs. The *Debit* dummy equals 1 if the option trade required an upfront payment. We standardize Delta, Gamma, Vega, and IV and include date fixed effects.

	(1)	(2)	(3)	(4)	(5)
α	-0.141	-0.141	-0.165	-0.015	0.066
	(-315.7)	(-316.2)	(-319.3)	(-21.5)	(1.4)
Delta	-0.001	-0.003	-0.002	-0.002	-0.002
	(-2.5)	(-7.0)	(-5.0)	(-4.2)	(-4.0)
Gamma	0.019	0.010	0.030	0.043	0.045
	(41.6)	(21.6)	(58.7)	(83.3)	(88.0)
Vega	0.018	0.063	0.073	0.094	0.088
	(39.8)	(116.4)	(131.8)	(170.6)	(159.3)
IV		-0.083	-0.053	-0.049	-0.084
		(-159.9)	(-87.0)	(-80.2)	(-105.4)
Complex			0.170	0.171	0.082
			(91.4)	(92.5)	(39.0)
Debit				-0.293	-0.290
				(-325.1)	(-335.1)
adjusted R^2	0.06	0.42	0.54	1.99	10.20
Date FE	No	No	No	No	Yes

We include the trade's total Delta as a measure of the directional risk taken on by the investor, the trade's total Gamma as a rough proxy for the position's tail exposure (Dew-Becker et al., 2021), and the trade's total Vega to capture volatility exposure. For multi-leg positions, the Greeks are simply the sum of the Greeks of the individual contracts that are part of the complex strategy. We also include the trade's average implied volatility, a dummy that equals 1 if the trade consists of a complex (multi-leg) position, and if it generated a net debit position (it cost money upfront to enter the trade).

In column (1) of Table 5, we include only the trade's Greeks. Consistent with the idea that investors are being compensated for taking on riskier positions, we find that the trades generate larger returns if their Gamma and Vega is higher. A one standard deviation increase in Gamma (Vega) generates a 0.019% (0.018) larger return over the remaining lifetime of the options of less than a day. The intercept (α) is negative and highly significant. Once we also include the trade's average implied volatility (IV), we find that the return influence of volatility risks is elevated, such that the same one standard deviation increase in Vega now generates 0.063% larger returns. In contrast, the

impact of Gamma is attenuated but remains highly significant. The impact of IV itself is negative, consistent with the idea that retail investor trades are particularly poor in high-IV contracts and in high-IV times.

We find corroborating evidence for the result in Table 4 that the median return of many multi-leg strategies is indeed positive in column (3): complex positions on average generate a larger return of 0.17%, which is roughly as large in absolute magnitude as the negative α. The dummy for whether the strategy required an upfront payment (Debit) has a highly significant and negative influence on 0DTE option returns (-0.293%). This in turn reflects the average additional compensation for the option seller. Including both the Complex and Debit dummy further elevates the influence of the risk proxies Vega and Gamma. Their inclusion also significantly lowers the unconditional α to -0.015%. In column (5) we also add day fixed effects, which renders the unconditional α statistically insignificant. The positive effect of complex trades is cut roughly in half (0.082%) but remains highly significant. The effects of the other variables are unchanged by the inclusion of day fixed effects.

4.3. 0DTE Expensiveness and Retail Trade Direction

The poor performance of aggregate retail trading in 0DTE options is potentially driven by a neglect of retail investors to take the options' expensiveness into account. To understand the motives behind the aggregate trading activity of retail investors, we relate the expensiveness of the transacted contracts to the trades' profitability. For a measure of the overall expensiveness of 0DTE options, we compute a VIX from realized trades in 0DTE options within each 10 minute window of a trading day. This pools the information of *realized* trades and their prices. We interpolate the option prices between the strike prices of options for which we observe a trade. We follow Berger, Dew-Becker, and Giglio (2020) and fit the SVI model of Gatheral (2006) through the reported implied volatilities of all out-the-money 0DTE S&P 500 option trades that occur within each 10-minute window using the methodology of Zeliade (2012). The resulting implied volatilities are subsequently reverted into option prices and the ultra-short-term VIX is estimated as:

$$\mathrm{VIX}_t^{\mathrm{0DTE}} = \frac{2e^{rT}}{T} \sum_{K_i} O_t(K_i, T) \Delta K_i. \tag{5}$$

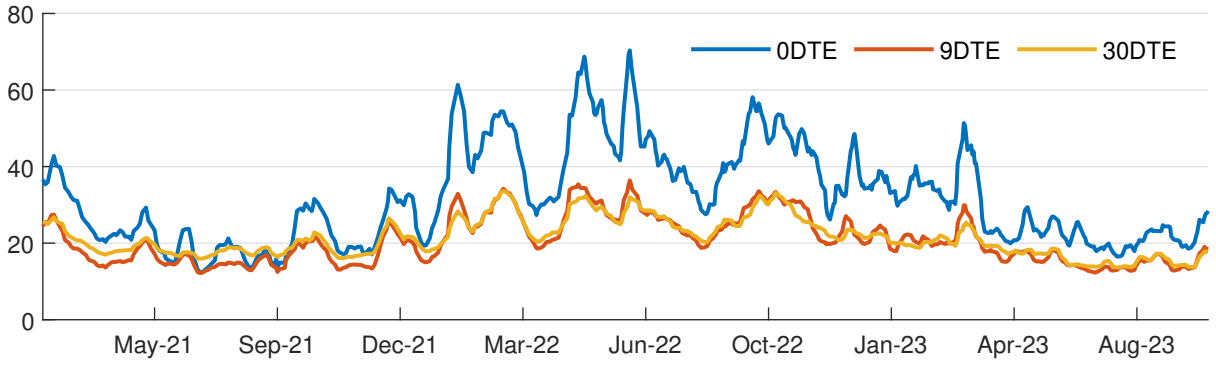

Fig. 8. 5-day moving average of the 0DTE, 9DTE and 30DTE opening VIX level

The figure shows the 5 day moving average level of the 0-day, 0-day and 30-day opening VIX from January 2021 until September 2023. The 9-day and 30-day opening VIX are provided by the Cboe. The 0-day VIX is calculated by fitting the SVI model of Gatheral (2006) through the reported implied volatilities of all out-the-money 0DTE SPX option trades that occur between 9:30 and 9:40 for each day using the methodology from Zeliade (2012).

Accordingly, the VIX^{0DTE} is an intuitive measure for the overall *realized* expensiveness of 0DTE options, as it is a direct result of traded prices.[8]

In Figure 8, we show the time-series of VIX^{0DTE}, measured each day with trades between 9:30 and 9:40. For reference, we overlay the opening 9-day VIX in orange and the opening 30-day VIX in yellow, both taken from Cboe's website. For better visibility, we plot 5-day moving averages. As we would expect, we find a downward-sloping term structure. VIX^{0DTE} is larger than the 30-day VIX for most of our sample. Interestingly, we find an inverse effect when comparing the 9-day with the 30-day VIX. The former tends to be at the same level, or even below the latter. At the beginning of 2022 we start seeing a distinct disconnect between the ultra-short-end and the remainder of the VIX term structure. VIX^{0DTE} has increased drastically, whereas both the 9-day and 30-day VIX have remained at their previous levels. Throughout 2022, the level of the VIX^{0DTE} sees several spikes above 60. Both the 9- and 30-day VIX are reasonably calm for our sample period, as both hover around 20 with occasional spikes to 30. In line with this, the financial press has picked up on the notion of 'The "broken" VIX'.[9] The introduction of a fine daily expiration grid may have contributed to a relatively calm 9- and 30-day VIX, with most of the variation in expected volatility now captured by VIX^{0DTE}. Starting in April of 2023, we find that VIX^{0DTE} starts to reapproach the levels of the 9- and 30-day

[8] After the dissemination of the first version of this paper, Cboe has announced and introduced their own version of an ultra-short-term VIX, which uses intraday quotes instead of trade prices: https://www.cboe.com/us/indices/dashboard/VIX1D/.

[9] https://www.ft.com/content/90224106-f6a2-4ca9-b053-77f51a493677.

Table 6: 0DTE Retail net and gross profits and option expensiveness

The table depicts regressions of the net and gross profits as in equation 3 in 0DTE Retail options on the standardized 0DTE VIX (VIX_t^{0DTE}) at a 10 minute frequency from 9:30 until 15:50 while using day fixed effects. The time series covers the full sample from February 2021 until September 2023 and the period of continuous offering of 0DTE options from May 16, 2022 until September 2023. We include date fixed effects. The t-statistics are given in parenthesis below and are calculated using Newey and West (1987) standard errors with optimal lag length.

	Full Sample		**From May 16^{th}, 2022**	
	$Profits_t^{Net}$	$Profits_t^{Gross}$	$Profits_t^{Net}$	$Profits_t^{Gross}$
α	-26163.7	-17480.9	-26990.8	-17480.9
	(-1.30)	(-0.96)	(-1.44)	(-0.96)
VIX_t^{0DTE}	-7077.0	-1660.0	-4326.3	-1660.0
	(-2.92)	(-0.50)	(-1.29)	(-0.50)
adjusted R^2	6.55	6.78	6.74	6.78
Date FE	Yes	Yes	Yes	Yes

VIX, as a potential sign that option market participants have learned to better handle the new risks and opportunities posed by 0DTE options.

Next, we relate the profits and losses of retail investors made in 0DTE options to the options' overall expensiveness, which we proxy for by VIX^{0DTE}. First, we regress the aggregate hold-to-maturity dollar performance of all retail trades made within a 10-minute window on the contemporaneous VIX^{0DTE}. Table 6 shows that for the full sample, more expensive 0DTE options contribute to the poor performance of the aggregate retail portfolio. A standard deviation increase in VIX^{0DTE} results in \$1660 larger losses gross- and \$7077 larger losses net-of-fees. The coefficient is significant at the 1%-level only for the net-of-fees profits, which may arise as market makers increase spreads in 0DTE options with a rising VIX^{0DTE}. The second column replicates this analysis for the sample starting on May 16th of 2022, which marks the introduction of a daily expiration schedule for S&P 500 options. From May 2022 onward, the profits and losses of retail trades are unrelated to VIX^{0DTE}, both gross- and net-of-fees. This is indicative evidence that retail investors have in part learned to tilt their decisions to buy or sell 0DTE options in accordance with the options' overall expensiveness. Despite greater losses in the second half of the sample (Table 2), these results paint a nuanced picture of the ability of retail investors to adapt to changes in the market structure. Our dataset only allows us to document the behavior of the aggregate retail trading in 0DTE options. It is thus probable that a fraction of retail investors have leveraged their exposure with these options to place more informed trades (Seru, Shumway, and Stoffman, 2010; Linnainmaa, 2011).

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, which originate from 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. 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. Positions with a higher jump or volatility risk exposure, which we measure by the position's Gamma or Vega, respectively, generate larger returns, consistent with retail investors being compensated for taking on these risks. A trade's return is negatively related to its implied volatility. Complex trades are on average generate significantly larger returns, whereas trades that require an upfront payment (debit) perform significantly worse. As a final result, we provide preliminary evidence that retail investors in the aggregate have learned to navigate the 0DTE landscape over time, consistent with the "learning-to-trade" literature (Seru et al., 2010; Linnainmaa, 2011).

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