Profiting from Investor Mistakes: Evidence from Suboptimal Option Exercise

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Abstract

In the past few years, the U.S. options markets experienced a major inflow of retail investors, who are young and tech-savvy, yet largely inexperienced. We show that this trend coincides with an increase in call option contracts left suboptimally unexercised. Market makers (and other arbitrageurs) can benefit from these mistakes via so-called "dividend play" trades, which produce (virtually) riskless arbitrage profits. Exploiting transaction-level data and a new reporting requirement, we accurately identify dividend play trades and document rising profits from this strategy during the retail investor trading boom. Puzzlingly, however, arbitrageurs leave money on the table, forgoing about 50% of potential profits. We explore possible explanations for this puzzling behavior.

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1 Introduction

Over the past several years, financial markets witnessed an unprecedented inflow of retail investors. Lured by new zero-commission brokerage offers, introduced by an investing app Robinhood, millions of young and tech-savvy yet inexperienced investors have started trading stocks, options, and cryptocurrencies. At the peak of its popularity in late 2021, Robinhood alone reported 21.3 million monthly active users. It has been widely documented in the literature that retail investors make mistakes (see e.g., Barber and Odean (2001), Calvet, Campbell, and Sodini (2007); Barber and Odean (2013) provide an excellent overview). Our paper focuses on retail investor activity in the options market, from which Robinhood made 38% of its 2021 revenue.[1] Options are complex financial instruments, and one would expect the new generation of investors to make mistakes in their options transactions.

As a laboratory for the study of the transactions of sophisticated investors capitalizing on retail investor mistakes, we use the so-called "dividend play" trades, which are pairs trades that produce (virtually) riskless arbitrage profits for market makers and other arbitrageurs. These profits derive from call options left suboptimally unexercised before the underlying stock goes ex-dividend. It may be optimal to exercise an American call option on a dividend-paying stock before maturity, but the decision to exercise requires high investor sophistication (e.g., an application of an option-pricing model). We show that an inflow of inexperienced retail investors has boosted potential gains from this strategy. Exploiting the new reporting requirements, we identify all dividend play trades and document that, instead of harvesting all the arbitrage profits from suboptimally unexercised call options, market makers and other sophisticated arbitrageurs leave a half of potential gains to writers of these options (who are potentially other market makers). This puzzling behavior cannot be explained by arbitrageur costs or constraints.

We use two alternative approaches to classify retail trades in our data. Our first approach, commonly used in the industry, identifies small trades (up to 10 contracts) as retail.[2] Our second approach is from Bryzgalova, Pavlova, and Sikorskaya (2022) (BPS).[3] They argue that, because of the current practice that permits Payment For Order Flow (PFOF) in the U.S., most retail orders are routed to wholesalers. Wholesalers often execute

[1]As per the company's quarterly statements, in 2021 Robinhood's total net revenue was \$1.82 billion and its revenue from options \$689 million.

[2]For instance, Deutsche Bank and Bloomberg rely on small trades to proxy retail participation in options, see `https://markets.businessinsider.com/news/stocks/stock-market-outlook-retail-investing-shorts-trading-options-deutsche-bank-2021-1-1030005344`) and `https://www.bloomberg.com/professional/blog/gamestop-highlights-importance-of-option-related-equity-flows/`, respectively.

[3]See also Ernst and Spatt (2022) and Hendershott, Khan, and Riordan (2022).

retail orders via exchange mechanisms known as 'price improvement auctions'.[4] BPS exploit a new reporting requirement introduced by the Options Price Reporting Authority (OPRA) in November 2019 and classify trades that went through a trades executed through a single-leg price improvement mechanism, which they call SLIM trades. Both measures pick up a surge in retail investor trading activity in our sample. We supplement these measures by ticker mentions in `WallStreetBets`, an investing forum popular with the new generation of retail investors, and Robinhood user count provided by Robintrack. Our final proxy for retail investor interest in a ticker is the internalized volume in underlying equities, reported to the Financial Industry Regulatory Authority (FINRA).

Given the recent surge in retail investor activity, it is important to understand its implications for the behavior of arbitrageurs in the options market. We focus on one specific mistake that option investors make, for which we can cleanly identify the trading patterns of market makers and other arbitrageurs who exploit it. This mistake is a failure to exercise in-the-money call options before the underlying stock goes ex-dividend when it is optimal to do so.[5] To benefit from it, market makers and other arbitrageurs engage in a 'dividend play,' an arbitrage strategy that diverts windfall gains from the writer of the option that was suboptimally left unexercised. The strategy is normally executed on a physical exchange floor[6] and it is therefore available only to floor market makers and other floor participants. We exploit the new OPRA trade types to accurately classify such arbitrage trades and study the behavior of arbitrageurs. Due to the dividend play, the daily trading volume on last cum-dividend dates in in-the-money call options for which early exercise is optimal often exceeds trading volume on the remaining dates by several orders of magnitude. Even for SPY, the ticker with the most actively traded options in 2021, cum-dividend day volume is typically 14-53 times larger.[7]

Expected profits to floor market makers and other arbitrageurs from the dividend play trades have been growing rapidly during the recent retail investor boom. Most of this profit derives from the sheer increase in open interest due to investor inflow, coupled with

[4] All the option trades in the U.S. must be executed on exchanges. To execute a customer order, wholesalers often engage an affiliated market maker, who takes the other side of the order and brings the paired order to an exchange, entering it in a price improvement auction.

[5] We note that sometimes call options may be purchased as part of any strategy that involves holding multiple option contracts. In those circumstances, or whenever transactions costs overweigh profits from early exercise, exercising an option may not be optimal.

[6] Some exchanges facilitate these strategies by imposing daily fee caps for floor market makers and other floor traders engaging in them. See e.g., https://listingcenter.nasdaq.com/rulebook/phlx/rules/phlx-options-7, accessed January 12, 2022, for the dividend strategy fee caps imposed by PHLX. Over 2/3 of dividend play transactions in our sample are executed on PHLX.

[7] The lower bound compares the average cum-dividend date dollar trading volume in call options to an average across all days in our sample, while the upper bound compares to the average volume in a week prior to cum-dividend date.

a higher fraction of options that are left unexercised on cum-dividend dates. For the latter, we document that in the cross-section, arbitrage activity is higher in contracts with larger share of retail activity in the preceding week, as measured by SLIM share. Overall, traders engaging in dividend play behave like unconstrained arbitrageurs in harvesting the windfall gain from failures to exercise options.

There is, however, one striking pattern that emerges from our examination of dividend play transactions. Market makers and other arbitrageurs exploit only 50% of available arbitrage profits, leaving the rest on the table.[8] We show that market makers and other arbitrageurs often exploit profitable opportunities in one contract on a particular stock while leaving another very similar contract unexploited. Even when matching on profitability characteristics, we find that there is a large variation in arbitrageur participation. This is extremely puzzling. Market makers' daily fee on dividend play trades is capped by most exchanges on which dividend play trades take place. Furthermore, other trading costs are very low because such transactions are typically pre-arranged by pairs of market makers and, in our sample, actual transaction prices are close to the midpoint of the bid-ask spread. We discuss the role of transaction costs in detail in Section 5.3.

We rule out further potential explanations of our money-left-on-the-table puzzle such as capital constraints and limited attention of arbitrageurs. The former is ruled out because market maker exposure is computed at a ticker level, and so the large long and short positions in contracts on the same ticker, required for the dividend play trade, are netted to zero. It is possible that the reluctance of some firms to engage in the dividend play arbitrage could be explained by the operational risk of the trade. It is also possible that there is a stigma associated with this strategy, since it is frowned upon by the U.S. Securities and Exchange Commission (SEC).

Finally, we caution against using the "Customer" classification provided by the Options Clearing Corporation (OCC) for identifying retail trades in our application. Our analysis reveals that a large fraction of dividend play trades, normally executed by arbitrageuers on the floor of an exchange, is classified as Customer trades by the OCC. It is highly unlikely that retail investors engage in the dividend play strategy.

Our paper offers several policy implications. First, retail brokerages should provide additional tools helping investors make sophisticated financial decisions that often accompany trading in options. For example, retail investors may not know how to compute an expected price of an option right after the underlying stock goes ex-dividend, and providing this valuation or making early exercise automatic, if optimal, would reduce option exercise

[8] Table 14 in the Appendix quantifies forgone profits of market makers in the top-40 most popular underlying stocks and ETFs for the dividend play strategy in our sample.

mistakes that we document in this paper.

Second, we discuss the difficulties of devising effective regulation in the derivatives market. Concerned about the impact of dividend play trades on the orderly functioning of the market, in 2014 the SEC issued a new rule designed to make the strategy impractical,[9] which resulted in much lower trading volumes on cum-dividend dates. However, the recent dramatic increase in options trading by inexperienced retail investors appears to have led to a resurgence of the strategy, whereby arbitrageurs have found a way to circumvent the barriers created by the SEC rule.

Our study relates to the growing literature on retail investor trading in the age of Robinhood. Welch (2022), Barber, Huang, Odean, and Schwartz (2022), Boehmer, Jones, Zhang, and Zhang (2021), and Eaton, Green, Roseman, and Wu (2021) focus on retail investor equity holdings and trading. Closest to our work in this literature is Bryzgalova, Pavlova, and Sikorskaya (2022), who analyze retail investor trading in the options market. In independent contemporaneous work, Ernst and Spatt (2022) and Hendershott, Khan, and Riordan (2022) propose the same method as BPS to identify wholesaler trades in the options market. Their main focus is on the price improvement (relative to the best prevailing quotes) achieved by wholesalers.

It has been previously documented that not all American options are exercised rationally (e.g., Poteshman and Serbin (2003)). Cosma, Galluccio, Pederzoli, and Scaillet (2020), Jensen and Pedersen (2016), and Barraclough and Whaley (2012) focus on early exercise decisions and show in more recent data that a fraction of investors still fail to exercise their options optimally. Hao, Kalay, and Mayhew (2009) and Pool, Stoll, and Whaley (2008) show how market makers exploit these mistakes by engaging in dividend play trades. Our measure of arbitrageur activity in dividend play, based on the new OPRA codes, is more accurate and it allows us to document surprising reluctance of market makers and other arbitrageurs to harvest arbitrage profits in certain contracts.

Our paper is also related to the limits-to arbitrage literature, such as Gromb and Vayanos (2002) and Shleifer and Vishny (1997). Fardeau (2021) explores arbitrageur behavior of in a setting with a limited number of arbitrageurs. In contrast to the studies of strategic arbitrageurs for whom price impact is a primary consideration, in our setting price impact is not a concern. Buy and sell orders in a dividend play strategy are entered at the same time and they are perfectly balanced. The dividend play trade is best compared to an IPO lottery: the windfall gain (from subotimal exercise of a call option contract) is effectively fixed and it is divided pro-rata between arbitrageurs who participate in the dividend play. Entry of additional arbitrageurs dilutes the share of the gain received by the existing

[9] See `https://www.sec.gov/rules/sro/occ/2014/34-73438.pdf`.

option writers.

The rest of the paper is organized as follows. Section 2 describes our dataset and the measures of retail trading. Section 4 investigates retail investors' failure to exercise options when it is optimal to do so and describes the arbitrageurs' dividend play strategy that exploits these mistakes. Section 5 documents the puzzling behavior of market makers, who leave money on the table, and attempts to rationalize this behavior. Section 6 makes several policy recommendations and Section 7 concludes. The Appendix presents some technical details and robustness checks.

2 Dividend play

In this section, we establish stylized facts suggesting that the inflow of retail investors has affected the behavior of arbitrageurs in the options market. Specifically, we focus on a particular arbitrage strategy, known as a dividend play, in which we can accurately identify trades of arbitrageurs. The inflow of inexperienced retail investors, who do not exercise their options optimally, has made this strategy more profitable for the arbitrageurs.

2.1 Dataset

Our options data comes from two main sources: OPRA and OptionMetrics. Transaction-level data from OPRA LiveVol is provided by CBOE. This data ranges from November 4, 2019 until July 31, 2021. It contains all transactions in index, ETF, and equity options on 16 U.S. options exchanges. In our analysis, we exclude index options and focus on single-name options on equities and ETFs. We use daily option price, volume, and open interest data from OptionMetrics. It comes at a contract level for the period between January 04, 1996, and June 30, 2021. We lag open interest for all the data after November 28, 2000, to have a series of consistent open interest as of the end of day.[10]

Our data cleaning procedure is as follows. Following the literature, we remove the first 15 and last 10 minutes in the day, canceled trades, trades with nonpositive size or price, negative spread (difference between best ask and best bid), and only keep trades for which trade price is above (best bid minus spread) and below (best ask plus spread). We aggregate trades of the same contract with the same quote time, exchange ID, trade price, and trade type into one line.

We complement this data by the options trading volume data from the OCC. The

[10]The lag is due to the change in the reporting format of OptionMetrics. This implies that end-of-day open interest is measured, therefore, after option exercises.

OCC data is daily and it is available from the OCC website in open access for the 24 months preceding its publication date. In our tests, we restrict our sample to the same time period, November 4, 2019 to July 31, 2021, as our OPRA sample.

For all stock data, we use CRSP. We obtain dividend history, stock prices and returns, outstanding shares, and rolling monthly volatility of daily returns. We rely on the SecId-PERMNO crosswalk provided by WRDS to link CRSP with OptionMetrics.

To construct a measure of internalized volume in the underlying, we rely on FINRA OTC Transparency data, which reports stock-level trading volume on automated trading systems (ATS), typically referred to as 'dark pools,' and non-ATS, with the latter representing internalized trades.This data is available from April 2016, by security and venue. Securities are split into NMS Tier 1, Tier 2, and OTCE. Details are on the website of FINRA: `https://otctransparency.finra.org/otctransparency/AtsIssueData`.[11]

For our WallStreetBets count measure, we download all comments from 'Daily Discussion' and 'What Are Your Moves Tomorrow' threads on `WallStreetBets` subreddit of `reddit.com`. This data is collected via PRAW, which is a Python API toolkit to access `reddit.com` for the period from October 1, 2019 to June 30, 2021. In particular, we download all the comments (original posts and reactions to them) for each daily'Daily Discussion' and 'What Are Your Moves Tomorrow' thread.[12]

Finally, we utilize Robintrack portfolio data, which is provided by Robinhood in intraday snapshots and covers May 5, 2018, to August 13, 2020.

2.2 Resurgence of dividend play

Daily trading volume in options on high-dividend stocks in the U.S. exhibits an intriguing seasonality, illustrated in Figure 1 for the case of UPS. The spikes in trading volume apparent from the figure occur every quarter, on the last cum-dividend date, i.e., the day before UPS pays a dividend. The average daily traded notional for UPS is \$125.3 million on cum-dividend dates and only \$2.5 million on the remaining dates. This pattern is common for options on high dividend paying stocks; Appendix A.3 presents more examples.

On cum-dividend dates, market makers (and other arbitrageurs) engage in an arbitrage trade known as the dividend play.[13] This strategy is available only for transactions originating from the floor of the exchange,[14] or, in other words, only to the market partici-

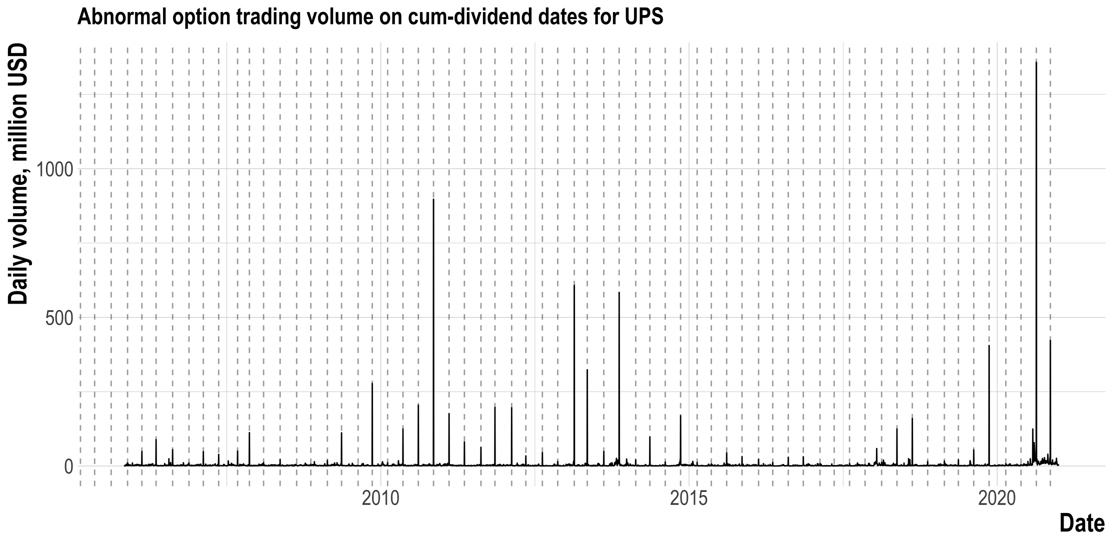
[11]See also FINRA's regulatory notice requiring reporting of this data: `https://www.finra.org/rules-guidance/notices/15-48`.

[12]Some dates are missing due to retrieval limitations on `reddit.com`. We interpolate between the neighboring dates to fill in those values.

[13]Pool, Stoll, and Whaley (2008) and Hao, Kalay, and Mayhew (2009) also study this trade.

[14]In fact, dividend play could be organized off the exchange floor but it would then not qualify for transaction

Figure 1: Abnormal trading volume on cum-dividend dates for UPS



This figure plots daily trading volume for all call option contracts on UPS, in millions of U.S. dollars, as reported in OptionMetrics. The dashed lines indicate cum-dividend dates.

pants who must be physically located on the trading floor. The strategy involves establishing long and short options positions that are so large that an operational error may potentially destabilize the market. Concerned about the impact of dividend play trades on the orderly functioning of the market, in 2014 the SEC issued a new rule designed to make the strategy impractical (see footnote 9), which resulted in much lower trading volumes on cum-dividend dates. However, the recent dramatic increase in options trading by inexperienced retail investors appears to have led to a resurgence of the strategy, despite the barriers created by the SEC rule.

The goal of the dividend play strategy is to take advantage of inattentive investors who fail to exercise their call options on dividend paying stocks when it is optimal to do so. It is optimal to exercise a call option if the value of exercising it on a cum-dividend date and collecting a dividend exceeds the value of the call the next day when the stock goes ex-dividend. Computing option values involves an application of the Black-Scholes-Merton formula or a more sophisticated option pricing method, which is typically difficult for novice retail investors. Alternatively, some retail investors may be unaware of the possibility of early exercise or are simply inattentive.[15] Since a fraction of in-the-money call options remains

fee caps. In our data, most abnormal volume on cum-dividend dates goes through floor trades on two exchanges, PHLX and BOX, as we discuss below.

[15] There might be other reasons why investors do not exercise, such as costs of unwinding more complex strategies. Hao, Kalay, and Mayhew (2009) show that dividend play profits outweigh such costs in most

suboptimally unexercised, the writers of these options would not be asked to deliver the stock and would profit from this inattention. It is a zero-sum game.

If all in-the-money call option contracts on a stock have been exercised on the cum-dividend date, all holders of short positions in the same contracts receive a request to deliver the stock. If some contracts are left unexercised, however, the U.S. Options Clearing Corporation (OCC) randomly 'assigns' short positions that must deliver the stock. The unassigned holders simply hold on to their options and profit from a capital gain. Market makers (and other arbitrageurs) can divert this capital gain to themselves by simultaneously buying and selling a large number of in-the-money call options on the same ticker.[16] They exercise all long positions and deliver on all assigned short positions. Since some fraction remains (suboptimally) not assigned, they capture dividends on their net long stock positions while staying fully hedged. Usually, two arbitrageurs agree on a dividend play trade in advance and serve as counterparty to each other on their arbitrage positions.

Table 1 illustrates the mechanics of the dividend play strategy by means of an example. Suppose there is 1 call option contract outstanding and it is optimal to exercise it.[17] Case 1 corresponds to the case when the option is exercised, the holder of the short position get assigned to deliver the underlying, and so there is no profit for a dividend play strategy to harvest. Case 2 describes what happens if the contract is left unexercised. Without arbitrageur involvement, the short position in the contract does not get assigned, and the option writer received a windfall gain of \$500 for sure. Now consider the entry of a market maker. The market maker attempts to pocket most of the potentially harvestable profit of \$500. To do so, the market maker buys and simultaneously sells 100 contracts and exercises all their long positions. The probability of assignment increases, but, because of the OCC's random assignment, with probability 100/101, the market marker holds the short position that does not get assigned and hence yields a gain. For the original option writer, this probability is now only 1/101. Hence, the expected gain of the market maker is \$495 out of the total gain of \$500 and that of the original option writer drops to \$5. A dividend play strategy, therefore, dilutes the share of the gain that accrues to the original option writer.

In what follows, we detect dividend play activity at a contract level in the full sample and characterize its importance relative to the overall trading volume on cum-dividend dates.

cases.

[16]The current SEC rule, presented in footnote 9, prohibits simultaneous buying and selling of the same contract.

[17]Appendix A.4 provides another example, in which there are multiple contracts outstanding, some of which are exercised optimally and some are not.

Table 1: Dividend play: An Example

	OI_{t-1} (A)	New positions(t) (B)	Available for ex. (C)	No. exercised (D)	Prob. non-assign. orig. option writer (E)	Prob. non-assign. market maker (F)	Gain per share (G)	Expected gain orig. option writer (E*G*100)	Expected gain market maker (F*G*100)
Case 1. Optimal exercise									
Customer	1	0	1	1	0		5	0	
Case 2. Suboptimal exercise									
Case 2.1. Without dividend play									
Customer	1	0	1	0	1		5	**500**	
Case 2.2. With dividend play									
Customer	1	0	1	0	1/101		5	**5**	
Market maker	0	100	100	100		100/101	5		**495**
Total	1	100	101	100					

This table illustrates the dividend play strategy. Date t refers to the cum-dividend date and OI_t stands for the open interest on date t.

2.3 Arbitrageur activity in dividend play strategy

We first present our novel measure of arbitrageur activity in the dividend play strategy. Through fee caps, exchanges incentivize cum-dividend day arbitrage strategies to originate from the physical floor. We therefore again exploit OPRA trade types to isolate option transactions that are executed on the floor. The trade types that cover most of the dividend play transactions are SLFT and MLFT, which are single-leg and multi-leg floor trades, respectively (see Appendix A.1 for a more detailed description). Other floor trade types, used infrequently in our sample are MLCT, MSFL, SLCN, TLFT, and TLFT. We analyze this measure in detail below and show that it very accurately captures dividend play trades in our sample. To our knowledge, this is the most precise measure of arbitrageur activity in the dividend play strategy in the literature, which typically uses trading volume on cum-dividend date in excess of the past average volume.

In our data, we see bursts of simultaneous buy and sell activity in neighboring-strike call option contracts, executed normally within several seconds, all coming from the floor. In an effort to reduce operationally risky dividend play trades, since 2014 the SEC forbids the market makers (and other arbitrageurs) to simultaneously buy and sell the same contract. Market participants have adjusted their trading strategies and they now simultaneously buy and sell neighboring contracts, which ultimately achieves the same objective. The trades are typically pre-arranged by pairs of market makers (or other arbitrageurs). We see no similar bursts of simultaneous buy and sell activity in call option contracts in any other OPRA trade types, which assures us that our measure very accurately captures arbitrageur activity

Table 2: Characteristics of activity on cum-dividend dates

	Average ticker dollar volume ($ million) on		**Total market dollar volume share (%) on**	
	cum-dividend date	any other date	cum-dividend date	any other date
	(1)	(2)	(3)	(4)
Panel A. Option type				
Call	24.9	1.5	92.8	54.3
Put	2.1	1.4	7.2	45.7
Panel B. Moneyness				
In the money	26.8	0.8	80.6	18.3
At the money	4.8	2.0	17.6	70.2
Out of the money	0.6	0.4	1.8	11.4
Panel C. Trade size				
Small	1.5	0.7	5.6	27.5
Large	31.0	2.8	94.4	72.5
Panel D. Floor trade				
Yes	48.2	0.9	76.9	6.5
No	6.1	2.4	23.1	93.5
Panel E. Exchange				
PHLX or BOX	24.6	0.5	79.7	15.0
Any other	5.5	2.3	20.3	85.0

This table compares option trading activity for dividend-paying tickers (2,153 stocks and ETFs) on cum-dividend date with any other date. The average volume in columns (1) and (2) is computed at ticker-day level, and the volume share in columns (3) and (4) is for the entire market. In Panel B, we define 'in the money' as $(Midpoint\,Price - Strike)/Strike > 0.1$ for call options and $(Midpoint\,Price - Strike)/Strike < -0.1$ for put options. 'At the money' are contracts for which this value is between -0.1 and 0.1, and 'out of the money' are all other contracts. In Panel C, we define trade as 'small' if the trade size is at or below 10 contracts. In Panel D, we define floor trades as trades with SLFT and MLFT OPRA trade types.

in the dividend play strategy.

Table 2 presents some descriptive statistics of trading activity on cum-dividend vs. any other dates for dividend-paying stocks and ETFs. We see an enormous difference in floor trading volume and volume of large trades on cum-dividend dates relative to other dates. Moreover, on cum-dividend dates we see a colossal spike in volume on two exchanges that cap fees for the dividend play strategy: PHLX and BOX. Breaking the trades by moneyness, we see that the primary increase in volume comes from trading deep-in-the-money calls (that are more likely to be optimal to exercise). This pattern is a signature of the dividend play strategy. The sheer size of the dividend play positions is astonishing, especially after the SEC passed a rule intended to clamp down on this strategy.[18]

3 Measures of retail investor popularity

We hypothesize that the resurgence of the dividend play strategy is related to the inflow of amateur retail investors, who do not exercise their options optimally. BPS show that during the pandemic-fueled retail investor boom, retail trading volume was over 48% of the total market trading volume. To test our hypothesis, we need a measure of retail trading activity in the options market.

3.1 Customer classification as a measure of retail activity

The first candidate measure to use is the "Customer" trading volume provided by the OCC on their website and used by researchers to identify retail investor transactions. To shed light on the accuracy of the OCC Customer volume in capturing retail activity, we contrast the OCC data with our measure of arbitrageur activity in the dividend play strategy, namely floor trades in pertinent call options on the last cum-dividend dates in the OPRA data. We are able to show that in the OCC data a very significant fraction of the trading volume in the dividend play strategy is attributed to Customer, i.e., a public customer. It is highly unlikely that public customers/retail investors participate in the dividend play strategy, which is a sophisticated strategy that involves very large long and short positions and that is normally executed on the exchange floor.

The following example illustrates the above statement. Table 3 provides the trading volumes from in OPRA and OCC for Microsoft option contracts during a short window that includes the last cum-dividend date, on which the dividend play strategy is executed (11/17/2020). In the OPRA data, we see a massive spike in floor trades, a signature of the

[18] See https://www.sec.gov/rules/sro/occ/2014/34-73438.pdf.

dividend play strategy. Notice that the growth in volume in the OCC data on the dividend play date comes from Customer and Market Maker categories. To provide further evidence that the abnormal trading volume on 11/17/2020 picks up dividend play activity, Table 9 in the Appendix breaks the OCC volume by exchange and compares it to a “normal” trading day (Table 10 in the Appendix): We see a clear increase in volume on several exchanges on the last cum-dividend date, in particular, on BOX and PHLX. Not all exchanges in the U.S. facilitate the dividend play strategy, and the fact that the abnormal volume comes from just two exchanges suggests that the dividend play strategy is at work. Again, a very large fraction of the increase in volume comes from Customer transactions. These examples easily generalize. Recall from Table 2 that 80% of trading volume on the last cum-dividend dates comes from floor trades. In the OCC data, much of this increased volume is attributed to Customer transactions. We therefore caution researchers against using the Customer flag in the OCC data to classify retail trades and suggest that papers relying on this flag should at least remove dividend play transactions from their sample.

Table 3: Trading volume on normal and dividend play dates: An example

	OPRA				OCC		
Date	Volume (mln contr.)	Volume ($ mln)	Floor (mln contr.)	Floor ($ mln)	Customer (mln contr.)	Total Off-floor (mln contr.)	Market Maker (mln contr.)
11/09/2020	289,265	131.522	245	0.113	264,635	279,953	327,241
11/10/2020	647,395	236.356	5,824	5.172	497,693	575,918	551,594
11/11/2020	303,515	153.100	638	1.824	224,568	236,950	247,488
11/12/2020	311,166	117.720	11,902	5.565	200,805	232,980	243,654
11/13/2020	252,664	101.164	3,746	2.320	195,420	205,790	214,086
11/16/2020	291,008	151.184	6,540	5.295	187,743	198,631	209,103
11/17/2020	464,769	1,674.898	176,323	1,452.843	268,631	355,234	436,364
11/18/2020	347,618	245.097	25,591	24.742	258,316	273,524	272,092

This table reports the trading volumes in Microsoft ~~call~~ option contracts in the OPRA and OCC data on normal days (11/09/2020-11/16/2022 and 11/18/2020) and on the last cum-dividend date (11/17/2020). For the OPRA data, we list both contract volume (mln contracts) and dollar volume. In the OCC data, the trading volume (mln contracts) is broken by Customer, Total Off-floor, and Market Maker. In the OCC volume data, each transaction is counted twice. The total OCC market volume adjusted for double-counting is given by the average of Total off-floor and Market maker volume. The OPRA and OCC volumes (adjusted for double-counting) do not exactly match because of our data filters (see Section 2).

We next turn to defining our two alternative, transaction-level measures of retail trading in options, as well as additional stock-based measures of retail investor popularity.

3.2 Measures of retail investor trading in options

All options trades in the U.S. must be executed on exchanges, and our transaction-level data contains every transaction in the U.S. options exchanges during the sample period. Using this data, we construct two measures of retail investor trading. Our first measure, often used in the industry, is the volume share of small trades (up to 10 contracts), *Small Share*. One could compute it as a frequency share and as a trading volume share. We adopt the latter definition, as it would be more relevant for assessing the influence of retail traders on asset prices. We compute it daily and, if necessary, we aggregate it to a ticker level using traded volumes.

We follow BPS and exploit unique features of our data allow us to construct a measure of retail investor trading in options (Ernst and Spatt (2022) and Hendershott, Khan, and Riordan (2022) propose the same methodology). We take advantage of the new trade type codes, introduced by OPRA on November 4, 2019, which provide a detailed classification of transaction types. This reporting requirement is significantly more detailed than its predecessors, and hence we can construct our measure only starting from November 4, 2019.

A highly publicized advantage to investors for having their orders routed to a wholesaler by a retail brokerage is that the wholesaler promises a price improvement to the customers, i.e., the execution price that is better than the best quoted price, known as National Best Bid and Offer, or NBBO. To meet this commitment, wholesalers often execute retail orders through a "price improvement auction" mechanism offered by options exchanges. The orders entered into an auction typically originate from the same wholesaler. A wholesaler can "bring" a *paired* order to the exchange to be "internalized" as long as the order is exposed to other market participants on that exchange. Market participants ("responders") have a window of time to respond with a better price for the agency order (hence, the name "price improvement mechanism/auction"), which could lead to the wholesaler losing the trade.[19] In practice, the fees are stacked against responders and it is often prohibitively expensive to break up one of these paired trades. See BPS for more detail. We borrow their terminology "SLIM" to denote trades that went through a single-leg price improvement mechanism, and use the volume share of these trades, *SLIM Share*, as a measure of retail activity.

3.3 Measures of retail investor popularity of a stock

We follow the literature to construct several measures of retail popularity of a stock. While these measures are all for stocks, we hypothesize that cash-constrained, risk-loving retail investors who bet on a stock may also trade options on this stock, which is a leveraged bet on the stock.

Our first measure of retail investor popularity, introduced in BPS, is a fraction of stock trading volume that was internalized on private trading platforms, off lit exchanges.

[19] Specifically, we use the same OPRA type 'SLAN,' which stands for single-leg non-ISO price improvement auctions. See Appendix A.1 for a description.

We utilize FINRA OTC Transparency data, and specifically stock-level non-ATS trading volume, which is internalized trading volume.

Our second measure of popularity is a ticker-level *WallStreetBets mentions*, which is based on `WallStreetBets` subreddit of `reddit.com`. We search for each unique historical ticker from CRSP in all the comments, and then simply sum the number of mentions by date. We only search for capitalized tickers as it is typical for the reddit audience to use those. Since we might omit any lower case mentions, and since we do not cover other threads of the forum (such as occasional megathreads), our measure provides a lower bound for ticker popularity.

Our final measure is Robinhood's breadth of ownership, used in e.g., Welch (2022), based on Robintrack portfolio data. Our measure of Robinhood's breadth of ownership is the number of users holding a stock as of the last intra-day snapshot.

4 Retail investor presence and failure to exercise

4.1 Failure to exercise and dividend play profits

In this section, we compute exploitable profits from a dividend play strategy. Some of these profits come from an increase in the open interest, some from investors' failure to exercise, and some from the value of early exercise of each contract. With an inflow of inexperienced investors in the options market, we expect the first two components to increase. We therefore find it useful to decompose the exploitable profit from a contract into three parts: the (i) open interest, (ii) fraction unexercised, and (iii) early exercise value.

The exploitable dividend play profit on all the interest for each contract is defined as

$$\pi_t = OI_{t-1} \times f_t \times EEV_t, \tag{1}$$

where $t-1$ is the day before the cum-dividend date, OI_{t-1} denotes open interest on that date (measured after all trades, exercises, and assignments on that date), $f_t \equiv OI_t/OI_{t-1}$ is the fraction unexercised, and EEV_t the early exercise value, computed below. Note that the fraction unexercised reflects the fraction of open interest in an option contract that remains outstanding after the cum-dividend date (after all trades, exercises, and assignments on that date). Both EEV_t and f_t are estimated quantities. Open interest as of the day before the cum-dividend day (OI_{t-1}) and fraction not exercised (f_t) are available from OptionMetrics. In rational and frictionless markets, we expect $f_t = 0$ if $EEV > 0$.

The early exercise value is model based, and we rely on the Black-Scholes-Merton option pricing formula to compute it.[20] Denote the expected ex-dividend price of an option by c_{ex}, its strike by K, and the current (cum-dividend) underlying stock price by S. The expected option ex-dividend price represents the expected time value of the option. *Early exercise value (EEV)* is therefore the difference between the current stock price, strike, and this expected time value of the option: $S - K - c_{ex}$.[21] The details of the computation of c_{ex} are in Appendix A.5.

In the following analyses, we restrict our sample to call option contracts that are optimal to exercise on cum-dates and refer to it as the *dividend play sample*. Further details related to its construction are provided in Appendix A.6, and Table 12 in the Appendix presents the descriptive statistics for our dividend play sample.

How do retail trading trends relate to cum-dividend date exercise rates? To answer this question, we run the following regression.

$$Y_{c,t} = \beta_1 \times share^{SLIM}_{c,t} + \beta_2 \times share^{small}_{c,t} + \boldsymbol{\gamma}' X_{c,t} + \alpha_{i,t} + \varepsilon_{c,t} \tag{2}$$

where, for each contract c on cum-date t, we consider two dependent variables, $Y_{c,t}$: Fraction of open interest not exercised by ex-dividend date and potential profits from dividend play strategy as defined in Equation (1). $share^{SLIM}_{c,t}$ is the average dollar volume share in SLIN trades, that is, those that went through single leg price improvement auctions, over one trading week before the cum-dividend date t, and $share^{small}_{c,t-h}$ is the average dollar volume share of trades up to 10 contracts over over one trading week before the cum-dividend date t. In some specifications we also use ticker-level measures of retail investor popularity such as *Non-ATS OTC share*, which is the share of internalized volume in the total trading volume of ticker i in the week of date t, and *WSB mentions, log*, the logarithm of the number of times ticker i was mentioned on `WallStreetBets` forum on date t. Our vector of controls $X_{c,t}$ includes the following contract-level variables: log OI, EEV, log dollar trading volume, relative spread, implied volatility, moneyness, days to expiry.[22] Our specification also includes the ticker by date fixed effects $\alpha_{i,t}$. Our measures of retail investor trading are computed over one trading week before the cum-date because the new generation of retail investors have a strong preference for options expiring within a week (as documented in

[20] To make sure our results are robust to the choice of the underlying pricing model, we considered the sample of broad-index ETFs and computed their corresponding option prices with the Merton and Bates models, following Bakshi, Cao, and Chen (1997) and Cosma, Galluccio, Pederzoli, and Scaillet (2020). Options on these ETFs represent over 10% of contracts in our dividend play sample and 55% of potential dividend play profits. All our results go through in that sample and are available upon request.

[21] Note that this definition is from Pool, Stoll, and Whaley (2008) and it is equivalent to the definition in Hao, Kalay, and Mayhew (2009). The latter uses dividend instead: $Dividend - c_{ex} + S_{ex} - K$.

[22] Since log OI and EEV are components of potential dividend play profits, we do not include them in the specification in Panel B below.

BPS). Table 15 in Appendix A.9 presents an alternative specification in which we measure retail trading over two weeks preceeding a cum-dividend date.

Panel A of Table 4 reports the results of the regression in (2), with the fraction of open interest unexercised as the outcome variable. We find that there is a strong positive relationship between retail investor trading and the fraction of options that were suboptimally not exercised on the cum-dividend day. We measure retail investor trading in two different ways—by the share of volume executed by wholesalers (SLIM trades) over the past week and by the share of small trades—and both variables come out as strong predictors of failures to exercise the option. A one standard deviation increase in the share of SLIM or small trades in the contract in the week preceding the cum-date raises the fraction unexercised by about one percentage point, depending on the specification. This result is robust and the magnitudes of the coefficients of interest do not change much as we relax the specification of fixed effects and switch on ticker-level controls instead (columns (1)–(3) and (5)-(6)).

Another measure of retail investor activity that strongly predicts the fraction left unexercised is the share of non-ATS OTC volume in the total trade volume in the underlying stock, measured over the preceding trading week, which proxies the share of internalized volume in the stock. We introduced this measure in Section 3.3. While this is a measure of retail investor trading in the underlying stock, it is correlated with retail investor trading in options on that stock. A call option is a leveraged position in a stock, and we hypothesize that some risk-loving retail investors may wish to trade options rather than the stock. We find that a one standard deviation increase in the non-ATS OTC share increases the fraction of options left unexercised by 1.6 percentage points (column (6)). Using another measure of retail trading discussed in Section 3.3, *WallStreetBets mentions*, we also find a positive and significant relationship between retail investor interest and the fraction unexercised.

One may argue that an alternative explanation for our findings is that the failures to exercise the options may be driven by transactions costs that make exercise impractical. To rule out this explanation, we restrict the sample to the top EEV tercile, the most profitable contracts to exercise (column (5)). We find that the size of the effect goes up significantly relative to our base case, implying that investor mistakes are a more likely driver of our findings. Another possible alternative explanation is that investors hold the call options in our sample as part of a sophisticated strategy, and exercising the option breaks one leg of the strategy. While this is possible and we do see mentions of a number of options strategies on `WallStreetBets`, we believe that the new generation of retail investors that drive our results are financial novices and relatively few of them engage in options strategies. Furthermore, to engage in such strategies, investors must qualify for a certain level of investment proficiency, required by investing platforms.

Table 4: Suboptimal exercise and retail investor popularity

	Dividend play profitability feature					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Fraction of OI not exercised, %						
SLIM Share	5.946***		5.791***	6.724***	5.792***	6.447***
	(3.48)		(3.37)	(2.66)	(3.38)	(3.58)
Small Share		4.438**	4.137**	10.365***	4.768**	4.569**
		(2.17)	(2.02)	(3.69)	(2.46)	(2.05)
Non-ATS OTC share						31.763*
						(1.88)
WSB mentions, log						0.528*
						(1.85)
Observations	21,105	21,105	21,105	6,942	21,105	19,134
Adjusted R-squared	0.237	0.237	0.238	0.345	0.214	0.213
Panel B. Potential profits, log U.S. dollar						
SLIM Share	1.465***		1.435***	1.701***	1.531***	1.564***
	(7.24)		(7.09)	(5.22)	(7.54)	(7.58)
Small Share		0.944***	0.873***	2.394***	0.887***	0.870***
		(3.27)	(3.08)	(4.09)	(3.27)	(3.04)
Non-ATS OTC share						2.991*
						(1.72)
WSB mentions, log						0.027
						(0.73)
Observations	21,105	21,105	21,105	6,942	21,105	19,134
Adjusted R-squared	0.307	0.304	0.308	0.314	0.286	0.292
Sample	All	All	All	Top EEV tercile	All	All
FE	Ticker*Date	Ticker*Date	Ticker*Date	Ticker*Date	Ticker and Date	Ticker and Date
Contract controls	Y	Y	Y	Y	Y	Y
Ticker controls	N	N	N	N	Y	Y

This table reports estimates of (2) in our dividend play sample. SLIM Share and Small Share are the contract-level volume shares of SLIM and small trades, respectively, averaged over one trading week before the cum-dividend date. Non-ATS OTC share is the ticker-level share of volume executed in the non-ATS OTC space relative to the total volume, averaged over one trading week before the cum-dividend date. WSB mentions, log, is the logarithm of total mentions of the ticker on *WallStreetBets* forum. In Panel B, contract controls include: log dollar trading volume, relative spread, IV, moneyness, days to expiry. In Panel A, they additionally include log OI and EEV. Ticker controls include: underlying price, underlying volatility, underlying relative bid-ask spread, underlying market cap. S.E. are clustered by ticker and date. Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel B of Table 4 considers the regression in (2), but with potential profits as the outcome variable. It reveals that the coefficients on all measures of retail activity are positive and significant: A one standard deviation increase in SLIM Share corresponds to around $4,200 higher profit *per contract*. In other words, the higher the retail activity in a contract in a week preceding the cum-dividend date, the more profitable it is for arbitrageurs to engage in a dividend play in the contract. Higher profits come from both (i) higher fraction unexercised (documented in Panel (a)) and (ii) higher open interest in the contracts popular with retail investors.

5 Money left on the table: A puzzle

In this section, we show that arbitrageurs engaging in the dividend play strategy leave money on the table by failing to capture arbitrage profits in some call option contracts. We explore the determinants of this puzzling behavior and present suggestive evidence that arbitrageurs may behave non-competitively.

5.1 Case study

November 11, 2020, was a cum-dividend date for UPS, a high-dividend paying stock, and a number of call options on UPS were deeply in-the-money and optimal to exercise on that day. Table 5 zooms in on a pair of such contracts, both expiring on November 20, 2020. We first compare the trading volume in the contracts on November 11, 2020. Notice that the trading volume in Contract 2 exceeds that in Contract 1 by two orders of magnitude. Notice also that Contract 2 has a very high share of orders from the trading floor on that day, while Contract 1 has zero. We also see characteristic bursts of floor orders in the transaction-level data for Contract 2. This means that market makers (or other arbitrageurs) engaging in a dividend play trade entered Contract 2 but not in Contract 1.

Table 5: Case study of arbitrageur activity: Two UPS call options on cum-dividend date

	Strike	EEV	OI (t-1)	Moneyness	Spread	Fraction not exercised	Cum-date volume	Floor share
Contract 1	160	0.29	1,945	3.15	0.045	0.76	45	0.000
Contract 2	155	0.43	2,487	4.62	0.039	0.47	3,255	0.998

Why did the arbitrageurs leave money on the table in Contract 1? The contract had a high EEV and a large fraction unexercised. Using equation (1) to compute the arbitrageur's forgone profits from not entering Contract 1, we arrive at $1,945 \times 0.76 \times 0.29 \times 100 \approx 42,900$ dollars, a significant sum.[23]

Trading costs do not explain the market participants' reluctance to trade Contract 1. First, exchanges offer daily fee caps for the dividend play strategy, and so if market makers (or other arbitrageurs) entered Contract 2, they should have also entered Contract 1. Second, contract bid-ask spreads in Table 4 are very similar. In the regression framework that follows, we further control for the options contract liquidity and show that trading costs do not explain why arbitrageurs forgo profitable opportunities.

It is very puzzling why arbitrageurs fully exploited the arbitrage opportunity in Contract 2 but not Contract 1. In the following section, we show that this pattern is general in our sample. The unexploited profit in Contract 1 accrued to the writer of this contract, which could be a market maker or perhaps a retail investor. The latter is less likely because retail brokerages take an automated action to close short positions that have dividend risk on behalf of their clients.[24] Appendix A.10 presents an excerpt from Robinhood's Terms and Conditions to provide an example of such automated action. It is therefore more likely that the writer of the contract who received the windfall gain was a market maker. The market maker who is a writer of the contract of course has no incentive to engage in a dividend play strategy in this contract because this would mean sacrificing own profit. But it is puzzling why other market makers or arbitrageurs would not wish to enter Contract 1 and reap arbitrage profits.

Table 14 in the Appendix generalizes this case study and reports forgone profits by ticker for the top 40 underlying stocks and ETFs sorted by the total size of forgone profits in our sample. We aggregate our data to and report the number of profitable individual contracts per ticker. The total amount of harvested profits in top-40 tickers in our sample is around \$51 million, whereas the total amount of forgone profit stands at \$67 million. For a virtually riskless arbitrage strategy, the amount of money left on the table is striking!

Furthermore, Table 14 does not reveal any particular pattern in harvested vs forgone profits: There is a large variation in arbitrageur participation across and within tickers. In what follows, we examine possible explanations for the puzzling reluctance of market participants to harvest arbitrage profits in some contracts.

[23] Each options contract in our sample is for 100 shares of the underlying stock or ETF.

[24] Since each options contract is for delivery of 100 shares of the underlying, for small retail investors the cash outlay needed for purchases of the underlying stock and delivering it could be quite significant. A brokerage would therefore close a short position if there are not enough funds in the account to buy and deliver the underlying.

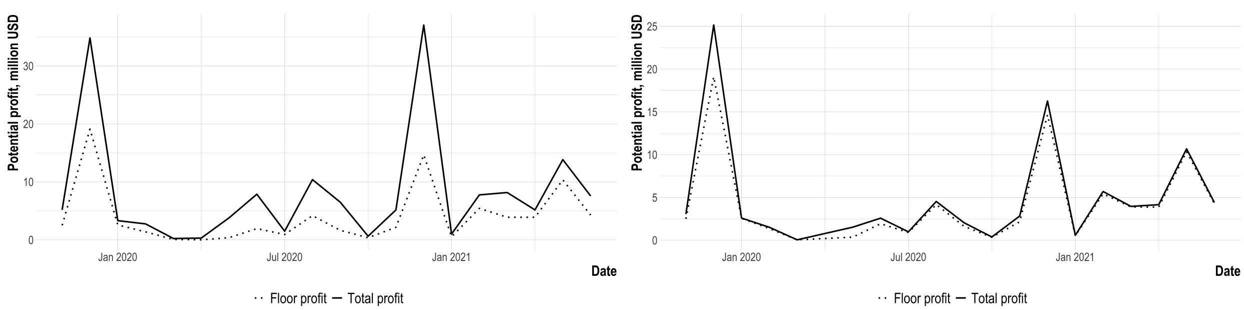
5.2 Drivers of arbitrageur activity

To examine drivers of arbitrage activity, we start by contrasting potential and harvested profits from the dividend play strategy on cum-dividend dates in our sample. Figure 2 presents potential profit of the dividend play strategy in all outstanding contracts, computed using equation (1), and profits harvested by floor traders. It emerges from panel (a), that a large fraction of potential profit, about 50%, remains unharvested. If we restrict the sample, however, to the contracts with non-zero floor trading volume—i.e., contracts in which we detect dividend play activity—most of the potential profit resulting from the failure of investors to exercise their options on cum-dividend dates is harvested. In other words, market makers (and other arbitrageurs) selectively enter profitable contracts, capturing almost 100% of exploitable gains, but forgo arbitrage profits in contracts they do not enter.

Figure 2: Total and floor trader profit from dividend play strategy

(a) All profitable contracts

(b) Contracts with non-zero floor share



This figure illustrates the implied share of potential dividend play profits captured by arbitrageurs on the trading floor. The solid plot is for the potential profit from the dividend play strategy and the dashed plot is for the profit harvested by floor traders (arbitrageurs).

The tendency of market makers (and other arbitrageurs) to leave money on the table in some profitable arbitrage opportunities is puzzling. In what follows, we try to understand the features on the contracts into which market participants are likely to enter.

The total exploitable profit is a calculated quantity, not known for sure on cum-dividend dates. The determinants of potential profit from a contract, however, are well-understood (see equation (1)), and projected fraction suboptimally unexercised is one of them. As we know from Table 4, this fraction is increasing in retail investor popularity. We therefore examine whether market makers (and other arbitrageurs) exploit increased investor inattention in contracts popular with retail investors. We estimate the following regression in the sample of contracts that should optimally be exercised on cum-date:

$$share_{c,t}^{floor} = \beta_1 \times share_{c,t}^{SLIM} + \beta_2 \times share_{c,t}^{Small} + \boldsymbol{\gamma}' X_{c,t} + \alpha_{i,t} + \varepsilon_{c,t}, \tag{3}$$

where the regressors are as in our previous specification (2) and the outcome variable is now the share of floor trades, which are predominantly market maker dividend play trades, in contract c on date t. Table 6 reports the results of the regression.

Table 6: Arbitrageur activity and retail investor popularity

	Floor trading share on cum-date				**D(floor share > 0)**	**Floor trading volume, log**
	(1)	(2)	(3)	(4)	(5)	(6)
SLIM share	0.048***		0.037**	0.057*	0.036*	0.547***
	(2.59)		(2.11)	(1.87)	(1.89)	(3.43)
Small share		0.288***	0.286***	0.123*	0.301***	4.025***
		(6.41)	(6.39)	(1.66)	(6.53)	(8.53)
Observations	21,105	21,105	21,105	6,942	21,105	21,105
Adjusted R-squared	0.403	0.408	0.408	0.473	0.397	0.475
Sample	All	All	All	Top EEV tercile	All	All
Contract controls	Y	Y	Y	Y	Y	Y

This tables reports estimates of (3) in our dividend play sample. Floor trading share on cum-date is the contract-level volume share of trades executed on the traded floor in the total traded volume on the cum-dividend date. SLIM Share and Small Share are the contract-level volume shares of SLIM and small trades, respectively, averaged over one trading week before the cum-dividend date. Contract controls include: log OI, EEV, log dollar trading volume, relative spread, IV, moneyness, days to expiry. All regressions include ticker by date fixed effects. t-statistics are based on standard errors clustered by ticker and date (in parentheses). *** p<0.01, ** p<0.05, * p<0.1.

Table 6 reveals that arbitrageur activity, as measured by floor trading share, is positively related to both measures of retail investor trading over the preceding week. This means that market makers (or other arbitrageurs) are aware of and do exploit suboptimal exercise strategies of retail investors by engaging in more dividend play trades in contracts that have experienced elevated retail investor activity. The effects of SLIM and Small Shares are statistically significant across all specifications. The magnitudes of the effect can be interpreted as follows. A one standard deviation increase in SLIM (Small) Share increases the share of floor trading by about 0.048*100*0.16=1 (0.288*100*0.18=5) percentage point(s). The magnitude is similar for the extensive margin (column (5)): A one standard deviation increase in SLIM (Small) Share increases the probability of floor entry by around a half (five) percentage point(s). If, instead of the floor trading volume share, we use floor trading volume in a contract on the cum-dividend date as an outcome variable, we again see strong effects of retail investor participation in the contract (column (6)). All of these effects are highly statistically significant.

If we restrict our sample to the most profitable contracts (column (4)), the relationship between retail trading and arbitrageur activity weakens and becomes marginally significant. This is surprising, given that our earlier analysis documents that retail investors do not exercise more profitable contracts more (column (4) in Table 4), and therefore market makers (or other arbitrageurs) seem to leave money on the table in more profitable dividend play trades.

To ascertain the robustness of our results, we pursue an alternative empirical strategy, based on propensity score matching. Such empirical exercise brings us closer to the case study explored in Table 5. Matching is a natural strategy in our setup because the set of characteristics on which one should match options to keep the expected profitability constant is well understood. We, again, study the relationship between floor trading share on cum-dividend date and retail popularity. However, here we isolate contracts with high retail popularity (top decile of SLIM share or Small share of 100%)[25] and construct the control group of contracts matched on profitability characteristics from contracts with low retail popularity. In the basic set of characteristics, we use open interest, early exercise value, and moneyness. We also report results with the characteristics extended to relative spread and underlying price. The corresponding covariate balance plots are presented in Appendix A.11.

Table 7: Arbitrageur activity and retail popularity: Matched contracts

	Floor trading share on cum-date							
		Matched		OLS		Matched		OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(SLIM share top decile)	0.035***	0.039***	0.032***	0.019*				
	(2.82)	(3.67)	(3.10)	(1.79)				
D(Small share = 1)					0.033***	0.035***	0.042***	0.033***
					(3.99)	(5.03)	(6.19)	(4.82)
Observations	21,105	21,105	21,105	21,105	21,105	21,105	21,105	21,105
No. neighbors	1	10	10		1	10	10	
Short controls	Y	Y	Y	Y	Y	Y	Y	Y
Extended controls	N	N	Y	Y	N	N	Y	Y

This table reports the results of propensity score matching estimation and OLS estimates for the same set of contract characteristics in our dividend play sample. Columns (1)-(3) and (5)-(7) report ATE. SLIM and small share are the contract-level volume shares of SLIM and small trades, respectively, averaged over one trading week before the cum-dividend date. Short controls include: log OI, EEV, moneyness. Extended controls include relative spread and underlying price. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 generalizes our case study in Table 5 to the sample of all matched contracts from our dividend play sample.[26] We again see that contracts that had experienced a larger

[25] Results are robust to the choice of percentiles. Small share of 100% corresponds to the 57^{th} percentile in our sample.

[26] In fact, we can use matching on the same profitability characteristics to study arbitrageur entry. In

volume of retail trading in the week preceding the cum-dividend date are more targeted by the arbitrageurs. The magnitudes are very similar to those in Table 6. We vary controls and numbers of neighbors across our specifications in Table 7, and the magnitudes of the coefficients do not vary much. The coefficients are also statistically indistinguishable from the OLS estimates from the same specification (columns (4) and (8)), which offers further evidence that our results are robust.

5.3 Possible explanations

We now explore possible explanations for the puzzling tendency of dividend play arbitrageurs to leave money on the table. First, there exist dividend-play specific fee caps on PHLX and, more recently, BOX.[27] Those fee caps limit the total costs paid by the market maker on a particular day at the options class level: Harvesting the profit from an additional contract would not increase payments to the exchanges once the limit is hit. Second, given that dividend play usually requires two participating parties, it is highly likely they agree on the transaction price that allows for mutually beneficial profit sharing. There is no clear reason why they would omit any particular contract from their agreement due to its otherwise lower liquidity. Finally, in the above analysis, we always control for contract liquidity or match on contract relative spread. It is therefore unlikely that the contracts in which market makers (or other arbitrageurs) do not engage in dividend play are systematically less liquid.

Another potential explanation is that arbitrageurs' capital constraints bind. However, most regulatory requirements typically involve netted positions, which are relatively low given the symmetric and fully hedged nature of the strategy. So it is not clear why capital constraints may bind unless they bind due to the arbitrageurs' internal risk management guidelines. Relatedly, such large trades are associated with high operational risks. According to SIFMA, Bank of America Merrill Lynch incurred a \$10 million loss due to a human error when executing the dividend play strategy.[28] Still, such explanations cannot produce the variation in floor trader activity within and across tickers that we document: Table 14 illustrates that there are many profitable contracts in which floor traders do not enter at all.

Finally, it has been documented that even sophisticated market players exhibit limits

Appendix A.12, we show that across the propensity score spectrum, there exist contracts with both zero and positive floor volume (as we showed before, in the latter case floor traders represent almost 100% of trading so they seem to exhaust most of the potential profits). This result suggests that profitability characteristics do not predict entry very well, hence emphasizing the puzzle.

[27] See PHLX pricing schedule: `https://listingcenter.nasdaq.com/rulebook/phlx/rules/phlx-options-7` and BOX fee schedule: `https://boxoptions.com/regulatory/fee-schedule/`.

[28] See https://www.reuters.com/article/us-usa-options-apple-idUSKBN0IQ2FA20141106.

to attention (Kacperczyk, Nieuwerburgh, and Veldkamp (2016)). Indeed, there may be hundreds of potentially profitable contracts available to dividend play on each cum-dividend day (thousands in case of SPY). Perhaps, traders simply cannot evaluate all relevant pricing parameters, enter into an agreement with each other, and process the necessary number of trades? First, it is not clear why other exchange members do not enter to reap arbitrage profits if such limits exist. However, we went on to test this hypothesis more formally. To do so, we used the number of stock-level EPS (Hirshleifer, Lim, and Teoh (2009)) and macroeconomic announcements (Savor and Wilson (2014)) as proxies for limits to attention and did not find that those mattered for floor trader activity. These additional results are available upon request.

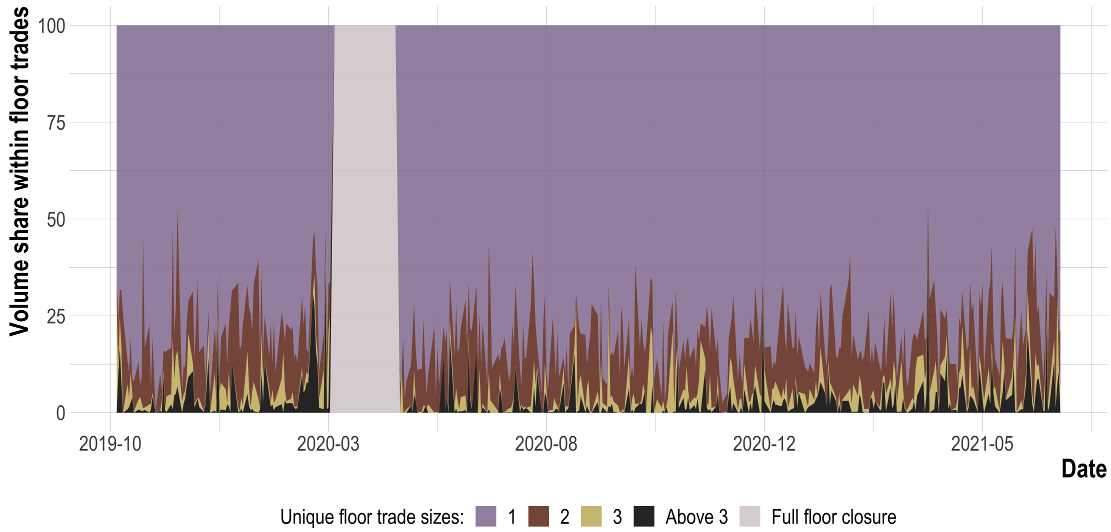
One alternative explanation that we cannot rule out is that some profits are left unexploited because of the stigma and reputational costs associated with the dividend play strategy. The SEC has clearly signaled its disapproval of the strategy in its 2014 Rule aimed at making the strategy impractical (see footnote 9). Reputational costs could explain the lack of entry of new arbitrageurs. However, they cannot explain why arbitrageurs who regularly engage in this strategy, and hence are willing to incur reputation costs, still leave money on the table.

5.4 How many arbitrageurs engage in dividend play?

This subsection provides suggestive evidence for the number of pairs of arbitrageurs simultaneously engaging in a dividend play strategy in a particular contract. Figure 3 plots a percentage split of dividend play trades by unique trade sizes, which is our proxy for a number of arbitrageurs engaging in dividend play in each contract.

The gray shaded area in Figure 3 corresponds to the closure of all exchange floors in the U.S. due to the COVID-19 pandemic. Our measure of floor trading is indeed zero over this period. Furthermore, the total trading volume on cum-dividend dates during the closures is the same as on any other day, which provides additional validation of the measure. Even when PHLX floor was closed but ARCA and BOX floors were open, the mean trading volume on cum-dates was an order of magnitude lower.

Figure 3: Floor trading by number of floor trade sizes



This figures depicts percentage split of trades executed on exchange floor by the number of unique trade sizes, i.e., the number of pairs of arbitrageurs. We only include contracts in our dividend play sample. The gray shaded area corresponds to the period of floor closures on all exchanges.

6 Discussion and policy implications

It is apparent from our analysis that the new generation of investors, while tech-savvy and active on investing forums, is still lacking in financial education that is required to trade options. These investors are likely to make mistakes in sophisticated financial decisions such as early exercise of an option, and these mistakes generate transfers from retail investors to arbitrageurs or market makers.

It is not clear whether retail investing platforms have the right incentives to prevent their customers from making trading mistakes. The question of optimal options exercise requires knowledge of option pricing models, which retail investors are likely to be lacking. One possibility would be to require retail brokerages to report options' early exercise values to investors. The early exercise value could be computed from the Black-Scholes model. Another possibility is to make *automatic* early exercise on cum-dividend dates when it is optimal to do so a default option for investors, from which they can opt out if they wish.

7 Conclusion

The new and inexperienced retail investors who entered the options market during the pandemic are more likely to suboptimally exercise their options. These mistakes can be exploited by arbitrageurs. We utilize newly-introduced transaction flags to isolate one specific trading strategy executed predominantly by market makers (and other arbitrageurs): the dividend play. This strategy capitalizes on early exercise mistakes and produces (virtually) riskless arbitrage profits for market participants. We document that market makers (and other arbitrageurs) engage in this strategy, amplifying tenfold or more the daily trading volume in affected tickers. However, puzzlingly, they do not take part in dividend play in some contracts, forgoing large profits. We rule out a number of explanations for this puzzling behavior and document that very few pairs of arbitrageurs engage in the dividend play strategy in a given contract on the same day, with a median of just one pair. Future research may be able to shed light on why dividend play arbitrageurs leave money on the table.

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A Appendix

A.1 OPRA trade types

The table below presents OPRA trade types, together with their descriptions, implemented on November 4, 2019. We also include the corresponding Trade Condition IDs from LiveVol, our data provider.

Table 8: OPRA trade types for transactions in U.S. options exchanges

OPRA Type Description	**OPRA Message Type**	**LiveVol Trade Condition ID**	**OPRA Condition Description**
AUTO		18	Transaction was executed electronically. Prefix appears solely for information; process as a regular transaction.
CANC		40	Transaction previously reported (other than as the last or opening report for the particular option contract) is now to be cancelled.
CBMO	Multi Leg Floor Trade of Proprietary Products	133	Transaction represents execution of a proprietary product non-electronic multi leg order with at least 3 legs. The trade price may be outside the current NBBO.
CNCL		41	Transaction is the last reported for the particular option contract and is now cancelled.
CNCO		42	Transaction was the first one (opening) reported this day for the particular option contract. Although later transactions have been reported, this transaction is now to be cancelled.
CNOL		43	Transaction was the only one reported this day for the particular option contract and is now to be cancelled.
ISOI		95	Transaction was the execution of an order identified as an Intermarket Sweep Order. Process like normal transaction.
LATE		13	Transaction is being reported late, but is in the correct sequence; i.e., no later transactions have been reported for the particular option contract.
MASL	Multi Leg Auction against single leg(s)	125	Transaction was the execution of an electronic multi leg order which was “stopped” at a price and traded in a two sided auction mechanism that goes through an exposure period and trades against single leg orders/ quotes. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Solicitation Mechanism.
MESL	Multi Leg auto-electronic trade against single leg(s)	123	Transaction represents an electronic execution of a multi Leg order traded against single leg orders/ quotes.
MLAT	Multi Leg Auction	120	Transaction was the execution of an electronic multi leg order which was “stopped” at a price and traded in a two sided auction mechanism that goes through an exposure period in a complex order book. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Solicitation Mechanism.
MLET	Multi Leg auto-electronic trade	119	Transaction represents an electronic execution of a multi leg order traded in a complex order book.

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Table 8: OPRA trade types for transactions in U.S. options exchanges (cont.)

MLCT	Multi Leg Cross	121	Transaction was the execution of an electronic multi leg order which was “stopped” at a price and traded in a two sided crossing mechanism that does not go through an exposure period. Such crossing mechanisms include and not limited to Customer to Customer Cross and QCC with two or more options legs.
MLFT	Multi Leg floor trade	122	Transaction represents a non-electronic multi leg order trade executed against other multi-leg order(s) on a trading floor. Execution of Paired and Non-Paired Auctions and Cross orders on an exchange floor are also included in this category.
MSFL	Multi Leg floor trade against single leg(s)	126	Transaction represents a non-electronic multi leg order trade executed on a trading floor against single leg orders/ quotes. Execution of Paired and Non-Paired Auctions on an exchange floor are also included in this category.
OPEN		6	Transaction is a late report of the opening trade and is out of sequence; i.e., other transactions have been reported for the particular option contract.
OPNL		7	Transaction is a late report of the opening trade, but is in the correct sequence; i.e., no other transactions have been reported for the particular option contract.
OSEQ		2	Transaction is being reported late and is out of sequence; i.e., later transactions have been reported for the particular option contract.
REOP		21	Transaction is a reopening of an option contract in which trading has been previously halted. Prefix appears solely for information; process as a regular transaction.
SCLI	Single Leg Cross ISO	117	Transaction was the execution of an Intermarket Sweep electronic order which was “stopped” at a price and traded in a two sided crossing mechanism that does not go through an exposure period. Such crossing mechanisms include and not limited to Customer to Customer Cross.
SLAI	Single Leg Auction ISO	115	Transaction was the execution of an Intermarket Sweep electronic order which was “stopped” at a price and traded in a two sided auction mechanism that goes through an exposure period. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Solicitation Mechanism marked as ISO.
SLAN	Single Leg Auction Non ISO	114	Transaction was the execution of an electronic order which was “stopped” at a price and traded in a two sided auction mechanism that goes through an exposure period. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Soliciation Mechanism.
SLCN	Single Leg Cross Non ISO	116	Transaction was the execution of an electronic order which was “stopped” at a price and traded in a two sided crossing mechanism that does not go through an exposure period. Such crossing mechanisms include and not limited to Customer to Customer Cross and QCC with a single option leg.

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Table 8: OPRA trade types for transactions in U.S. options exchanges (cont.)

MLCT	Multi Leg Cross	121	Transaction was the execution of an electronic multi leg order which was "stopped" at a price and traded in a two sided crossing mechanism that does not go through an exposure period. Such crossing mechanisms include and not limited to Customer to Customer Cross and QCC with two or more options legs.
SLFT	Single Leg Floor Trade	118	Transaction represents a non-electronic trade executed on a trading floor. Execution of Paired and Non-Paired Auctions and Cross orders on an exchange floor are also included in this category.
TASL	Stock Options Auction against single leg(s)	131	Transaction was the execution of an electronic multi leg stock/options order which was "stopped" at a price and traded in a two sided auction mechanism that goes through an exposure period and trades against single leg orders/ quotes. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Solicitation Mechanism.
TESL	Stock Options auto-electronic trade against single leg(s)	130	Transaction represents an electronic execution of a multi Leg stock/options order traded against single leg orders/ quotes.
TFSL	Stock Options floor trade against single leg(s)	132	Transaction represents a non-electronic multi leg stock/options order trade executed on a trading floor against single leg orders/ quotes. Execution of Paired and Non-Paired Auctions on an exchange floor are also included in this category.
TLAT	Stock Options Auction	124	Transaction was the execution of an electronic multi leg stock/options order which was "stopped" at a price and traded in a two sided auction mechanism that goes through an exposure period in a complex order book. Such auctions mechanisms include and not limited to Price Improvement, Facilitation or Solicitation Mechanism.
TLCT	Stock Options Cross	128	Transaction was the execution of an electronic multi leg stock/options order which was "stopped" at a price and traded in a two sided crossing mechanism that does not go through an exposure period. Such crossing mechanisms include and not limited to Customer to Customer Cross.
TLET	Stock Options auto-electronic trade	127	Transaction represents an electronic execution of a multi leg stock/options order traded in a complex order book.
TLFT	Stock Options floor trade	129	Transaction represents a non-electronic multi leg order stock/options trade executed on a trading floor in a Complex order book. Execution of Paired and Non-Paired Auctions and Cross orders on an exchange floor are also included in this category.

This table reports OPRA trade types and their descriptions. The type of each transaction in U.S. options exchanges has to be classified using a type description from the table and reported to OPRA. This reporting requirement was implemented on November 4, 2019.

A.2 Customer classification in the OCC data

The extant literature has relied on a Customer flag, offered by some options data providers, to identify retail trading activity. The tables below provide a further example that in the OCC data a significnt fraction of the trading volume in the dividend play strategy is attributed to Customer transactions.

Table 9: Trading volume on a dividend play date: An example

Trading volume on last cum-div. date – 11/17/2020 (mln contracts)						
Ticker	Exchange	Customer	Firm	Off-Floor	Market Maker	Total
MSFT	AMEX	9,974	10,326	20,300	12,800	33,100
	BOX	9,094	7,110	16,204	44,722	60,926
	CBOE	38,285	10,827	49,112	30,318	79,430
	EMLD	8,952	126	9,078	8,600	17,678
	EDGX	6,400	280	6,680	6,910	13,590
	CFE	21,019	313	21,332	20,334	41,666
	ISE	17,590	877	18,467	18,707	37,174
	MCRY	2,056	25	2,081	2,321	4,402
	MIAX	6,285	234	6,519	7,173	13,692
	ARCA	13,072	1,460	14,532	14,524	29,056
	NSDQ	16,405	2,471	18,876	35,944	54,820
	MPRL	5,098	252	5,350	6,874	12,224
	SML	75	43	118	308	426
	C2	2,816	575	3,391	4,993	8,384
	PHLX	97,749	48,067	145,816	194,666	340,482
	BATS	13,761	3,617	17,378	27,170	44,548
Ticker Total		268,631	86,603	355,234	436,364	791,598

This table reports the trading volumes in Microsoft option contracts, as reported by the OCC on the last cum-dividend date, 11/17/2020. The trading volume (million contracts) is broken by Customer, Firm, Total Off-floor, and Market Maker. There are large spikes in volume on AMEX and ISE relative to a normal day, reflecting the dividend play activity on that day. The reported OCC figures double-count each transaction. To reconcile the numbers with the OPRA volume, one needs to divide them by two.

Table 10: Trading volume on a normal day: An example

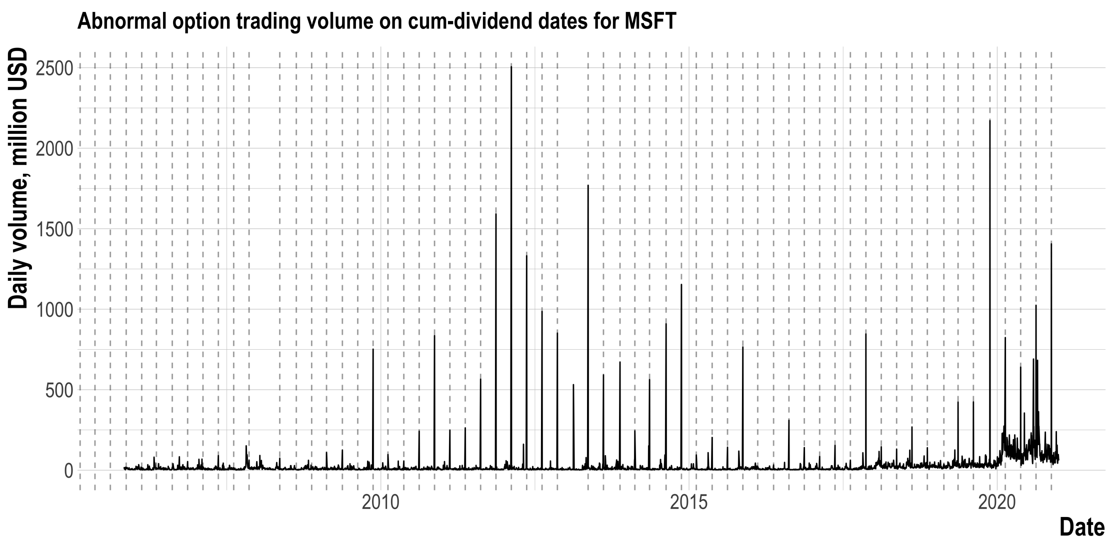
Trading volume on a normal day – 11/12/2020 (mln contracts)						
Ticker	Exchange	Customer	Firm	Off-Floor	Market Maker	Total
MSFT	AMEX	12,736	612	13,348	14,610	27,958
	BOX	2,505	79	2,584	4,282	6,866
	CBOE	20,208	7,839	28,047	28,473	56,520
	EMLD	13,744	27	13,771	13,159	26,930
	EDGX	7,745	1,874	9,619	6,715	16,334
	CFE	20,146	201	20,347	18,719	39,066
	ISE	16,318	3,355	19,673	19,037	38,710
	MCRY	2,342	0	2,342	2,244	4,586
	MIAX	6,502	339	6,841	6,859	13,700
	ARCA	22,946	6,262	29,208	15,832	45,040
	NSDQ	20,571	1,343	21,914	46,410	68,324
	MPRL	5,118	291	5,409	6,557	11,966
	SML	338	1	339	371	710
	C2	3,440	764	4,204	5,708	9,912
	PHLX	29,200	5,892	35,092	23,792	58,884
	BATS	16,936	3,296	20,232	30,876	51,108
Ticker Total		200,795	32,175	232,970	243,644	476,614

This table reports the trading volumes in Microsoft option contracts, as reported by the OCC on a normal day, 11/12/2020. The trading volume (million contracts) is broken by Customer, Firm, Total Off-Floor, and Market Maker. There are large spikes in volume on AMEX and ISE relative to a normal day, reflecting the dividend play activity on that day. The reported OCC figures double-count each transaction. To reconcile the numbers with the OPRA volume, one needs to divide them by two.

A.3 Abnormal trading volume on cum-dividend dates: Further examples

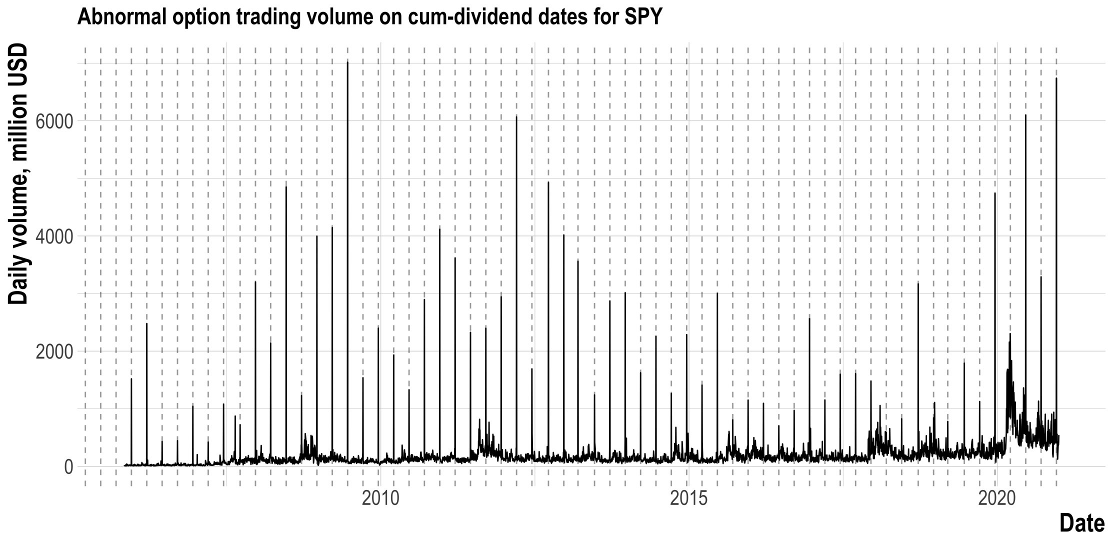
This appendix contains two further examples of abnormal trading volume on cum-dividend dates. The figures below plot daily trading volume of options on Microsoft, MSFT, and on the largest S&P 500 ETF, SPY.

Figure 4: Abnormal trading volume on cum-dividend dates for Microsoft



This figure plots daily trading volume for all call option contracts on MSFT, in millions of U.S. dollars, as reported in OptionMetrics. The dashed lines indicate cum-dividend dates.

Figure 5: Abnormal trading volume on cum-dividend dates for Microsoft



This figure plots daily trading volume for all call option contracts on SPY, in millions of U.S. dollars, as reported in OptionMetrics. The dashed lines indicate cum-dividend dates.

A.4 Dividend play: Another example

Table 11 provides an additional example illustrating the mechanics of the dividend play strategy. Case 1 corresponds to the case when all 1,000 outstanding contracts are exercised, all 1,000 short positions get assigned and so there is no profit for a dividend play strategy to harvest. Case 2 describes what happens if 500 of 1,000 outstanding contracts are left unexercised. Without arbitrageur involvement, half of the short positions in the contract get assigned; the remaining positions deliver a gain of \$0.5 per share and \$25,000 in total for the unassigned short positions, a gain to the original customers with short positions. Now consider the entry of market makers. The market makers attempt to recover most of the potentially harvestable profit of \$25,000. To do so, they buy and simultaneously sell 5,000 contracts and exercise all their long positions. The probability of assignment increases, but, because of the OCC's random assignment, some of the short positions of the market makers remain unassigned and hence yield a gain. In our example, market makers harvest \$20,850 out of the total gain of \$25,000. To divert a larger fraction of the total gain from the original customers with short positions, market makers simply increase the number of contracts they buy and sell.

Table 11: Dividend play: Another Example

	OI_{t-1}	New positions(t)	Available for ex.	No. exercised	Prob. Assign.	No. assign.	No. not assign.	Gain per share	Total gain on unassign. positions	OI_t	Fraction unex.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Case 1. Optimal exercise											
Customer	1000	0	1000	1000	100%	1000	0.00	0.5	0	0.00	
Case 2. Suboptimal exercise											
Case 2.1. Without dividend play											
Customer	1000	0	1000	500	50%	500	500	0.5	25000	500	0.5
Case 2.2. With dividend play											
Customer	1000	0	1000	500		916.7	83.33	0.5	4166.7		
Market makers	0	5000	5000	5000		4583.3	416.67	0.5	20833.3		
Total	1000	5000	6000	5500	92%	5500	500		25000	500	0.5

This table illustrates the dividend play strategy. Date t refers to the cum-dividend date and OI_t stands for the open interest on date t. This table is similar to Table 1 in Pool, Stoll, and Whaley (2008).

A.5 Dividend play: Technical details

We compute the expected call option ex-dividend price using Black-Scholes-Merton formula:

$$
\begin{aligned}
c_{ex} &= S_{ex}e^{-y(T-t)}N(d_1) - Ke^{-r(T-t)}N(d_2) \\
d_1 &= \frac{1}{\sigma\sqrt{T-t}} ln\left(\frac{S_{ex}}{K} + \left[r - y + \frac{\sigma^2}{2}\right](T-t)\right) \\
d_2 &= d_1 - \sigma\sqrt{T-t} \\
y &= Dividend_{ex}/S_{ex}
\end{aligned}
$$

where S_{ex} is the expected price after the stock goes ex-dividend, i.e., price at close on the cum-dividend day minus expected dividend, $T-t$ is time to maturity in years, i.e., difference in the expiration date and the current date in days divided by 360, K is the contract strike, σ^2 is the annualized implied volatility,[29] and r is the interpolated maturity-specific interest rate provided by OptionMetrics (annualized %), $Dividend_{ex}$ is the expected dividend after the ex-date.[30]

[29] We use the daily contract-level implied volatility from OptionMetrics. If it is missing, we interpolate it from the neighboring strikes.

[30] We assume that its size is equal to the current dividend if the stock pays one more dividend after the current dividend until the option expires and 0 otherwise.

A.6 Dividend play sample: Data filters and calculated variables

We use our dataset described in 2.1 together with the following filters to arrive at the final dividend play sample. We include all call option contracts with $EEV > 0$. Furthermore, since our valuation might be imperfect, we add a market-based filter of the optimality of exercise: We only keep contracts with a decline in open interest on the cum-dividend date.[31] By implication, we only have contracts with non-zero open interest on the cum-dividend date and the date before that.

Following the early papers on dividend play, we remove contracts with no trading volume on cum-dividend date. Additionally, we remove contracts expring immediately after the ex-dividend.[32]

To measure arbitrageur activity, we use floor trading share, defined as the total volume in transactions of OPRA types SLFT and MLFT, divided by the total volume on the cum-dividend date.[33] For both SLIM and Small Share, we compute a one-week moving average and use its lagged value on the cum-dividend date. We use the same rolling measures for the retail activity variables described in the main text, as well as volume, spread, and implied volatility controls.

We compute relative spread quoted at the time of each option trade as $2(best\,ask - best\,bid)/(best\,ask + best\,bid)$ (relative to the midpoint price). We compute moneyness of the trade as $0.5(underlying\,bid + underlying\,ask)/strike - 1$.[34]

[31] This is consitent with Hao, Kalay, and Mayhew (2009).

[32] The last filter does not change results significantly.

[33] In unreported tests, we confirm that using dollar volume based measures instead yields similar results.

[34] In the absence of TAQ data, we use underlying bid-ask midpoint as a high-frequency price.

Table 12: Dividend play sample descriptive statistics

	Mean	Median	St. Dev.	p1	p99
Fraction of OI not exercised, %	23.38	6.98	31.02	0.00	99.32
Floor trades volume share on cum-date	0.56	0.85	0.47	0.00	1.00
D(floor share > 0)	0.61	1.00	0.49	0.00	1.00
SLIM share	0.15	0.15	0.16	0.00	0.65
Small share	0.85	0.88	0.18	0.27	1.00
Non-ATS OTC share	0.17	0.16	0.05	0.07	0.30
WSB mentions	8.20	0.33	36.15	0.00	232.67
OI, log	4.97	4.89	1.99	0.69	9.80
Early exercise value (EEV), $	0.49	0.30	0.59	0.00	2.79
Market EEV, $	0.08	0.02	0.39	-0.41	1.12
Dollar potential profit	7,059.9	215.4	57,949.3	0.00	121,549.1
Dollar volume, log	4.16	4.09	1.40	1.17	7.85
Relative spread	0.07	0.04	0.09	0.00	0.46
Implied volatility, annualized	0.41	0.36	0.28	0.07	1.29
Moneyness	5.56	3.99	5.57	0.47	29.27
Days to expiry	67	21	124	4	625

This table reports descriptive statistics for all contracts in the dividend play sample (21,997 observations). SLIM and small share are the contract-level volume shares of SLIM and small trades, respectively, averaged over one trading week before the cum-dividend date. Non-ATS OTC share is the ticker-level share of volume executed in the non-ATS OTC space relative to the total trading volume, averaged over one trading week before the cum-dividend date. WSB mentions is the number of underlying ticker mentions on `WallStreetBets` forum, averaged over one trading week before the cum-dividend date. Relative spread is options contract quoted spread at the time of the trade relative to the midpoint price. Implied volatility is as reported in LiveVol, interpolated using nearest strikes if missing. Moneyness is measured as $(Midpoint\,Price - Strike)/Strike$.

A.7 OTC trading volume, by firm

Table 13: Top-15 firms in non-ATS OTC market in the U.S.

Firm	**OTC volume, billion shares**	**Venue share in total volume, %**	**Cumulative share, %**
CITADEL SECURITIES	477.82	44.31	44.31
VIRTU	357.61	33.16	77.47
SUSQUEHANNA	119.10	11.04	88.52
TWO SIGMA	48.50	4.50	93.01
JANE STREET CAPITAL	28.49	2.64	95.66
UBS	25.35	2.35	98.01
WOLVERINE	7.29	0.68	98.68
COMHAR CAPITAL MARKETS	3.84	0.36	99.04
HRT EXECUTION SERVICES	3.46	0.32	99.36
LEK SECURITIES CORPORATION	2.27	0.21	99.57
GOLDMAN	2.20	0.20	99.77
ACS EXECUTION SERVICES	0.44	0.04	99.81
IMC	0.32	0.03	99.84
MORGAN STANLEY	0.29	0.03	99.87
COWEN	0.28	0.03	99.90

This table reports the top-15 firms in terms of their total OTC non-ATS volume in 11/2019-06/2021. Based on FINRA OTC Transparency data.

A.8 Dividend play profits by ticker

Table 14: Dividend play profits by ticker

	Profit, USD		No. contracts			Traded volume (contracts)
Ticker	**Harvested**	**Foregone**	**Fully harvested**	**Partly harvested**	**Foregone**	
Ticker	(1)	(2)	(3)	(4)	(5)	(6)
SPY	2,395,306.0	23,600,000.0	228	38	991	722,404
AAPL	3,464,514.0	8,591,433.0	302	129	238	849,464
EEM	10,800,000.0	4,907,643.0	142	5	46	5,266,442
IWM	1,484,462.0	3,528,205.0	51	3	162	512,940
EFA	2,436,712.0	3,324,776.0	97	7	25	1,087,908
XLE	1,794,247.0	2,844,799.0	171	7	91	447,875
VALE	1,913,317.0	2,737,224.0	66	6	11	1,876,400
QQQ	105,585.1	2,039,488.0	23	2	208	27,750
EWZ	3,374,398.0	1,330,285.0	87	1	31	1,327,432
KO	440,711.1	1,097,762.0	76	23	66	322,120
HYG	36,411.0	912,840.1	11	4	57	63,710
SAN	-	753,484.1	0	0	11	-
HD	936,386.6	674,275.4	95	21	96	197,887
COST	1,703.4	658,710.4	11	4	43	1,207
XLF	478,434.8	620,190.3	57	5	57	344,130
IBM	684,029.4	567,198.3	116	116	36	383,594
BHP	176,163.5	553,367.0	33	4	12	57,055
DIA	156,767.9	539,148.9	60	8	146	17,401
ET	620,329.4	529,149.1	51	12	48	574,990
QCOM	749,520.4	497,014.1	68	16	49	426,659
GOLD	313,229.0	449,155.9	27	4	32	68,580
VIAC	1,770,252.0	420,720.0	97	1	51	437,395
XOM	8,123,625.0	404,302.2	242	82	62	1,734,910
XLI	10,843.2	401,816.1	12	1	15	17,123
RIO	27,621.1	375,591.7	16	4	5	57,782
XLP	116,856.2	370,016.7	16	0	32	15,990
T	2,700,908.0	369,322.1	155	35	47	2,381,173
JPM	883,655.1	365,889.3	80	32	37	1,096,394
CVX	623,103.9	320,866.8	234	86	91	419,757
FXI	877,237.6	309,056.5	77	4	18	1,242,431
GILD	355,846.2	308,605.1	65	23	43	280,310
MRO	-	307,556.9	0	0	23	-
NVDA	-	283,368.6	0	0	57	-
BP	339,841.9	277,599.5	99	28	52	209,456
DIS	836,205.3	273,563.9	41	5	1	503,899
PGR	661,473.3	263,863.8	12	5	20	56,496
MPC	561,419.5	251,516.0	105	47	64	418,852
TGT	90,064.5	241,550.0	77	29	66	65,810
DOW	138,056.3	231,155.0	32	13	61	92,369
PRU	68,932.0	224,236.2	33	29	18	85,664
Total	**50,548,168.7**	**66,756,745.0**	**3,165**	**839**	**3,219**	**23,691,759**

This table reports the top-40 tickers in terms of dividend play profits forgone by floor traders in our sample. Values are aggregated across all contracts within a ticker in 11/2019-06/2021. Total dividend play potential profits are computed as in Equation (1). To compute 'harvested' profits, we multiply the total profits by the floor volume share on cum-dividend date, and attribute the residual to 'forgone' profits. No. of 'fully harvested' contracts in column (3) is the number of contracts with floor share above 90%, and in column (5) – with zero floor share.[a] Traded volume in column (6) is the total floor trading volume in all contracts.

[a]The average floor share is over 99% in 'fully harvested' contracts and 69% in 'partly harvested' contracts.

A.9 Retail trading measured over a longer window

In this appendix, we redefine our retail trading measures. Instead of measuing shares of retail trading in the dollar trading volume in options over one trading week preceeding a cum-dividend date, we measure them over two trading weeks. Tables 15 and 16 are the analogs of Tables 4 and 6, respectiviely, but with the redefined measures of retail trading.

Table 15: Suboptimal exercise and retail investor popularity

	Dividend play profitability feature					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Fraction of OI not exercised, %						
SLIM share	7.460***		7.280***	7.689**	7.633***	7.628***
	(3.46)		(3.36)	(2.34)	(3.57)	(3.41)
Small share		5.120**	4.767**	12.893***	5.818***	5.041**
		(2.23)	(2.06)	(3.94)	(2.62)	(2.00)
Non-ATS OTC share						25.559
						(1.19)
WSB mentions, log						0.557*
						(1.69)
Observations	21,105	21,105	21,105	6,942	21,105	19,134
Adjusted R-squared	0.238	0.237	0.238	0.345	0.214	0.214
Panel B. Potential profits, log U.S. dollar						
SLIM share	1.970***		1.954***	2.238***	2.078***	2.040***
	(7.56)		(7.52)	(5.46)	(8.10)	(7.59)
Small share		0.568	0.485	2.504***	0.520	0.531
		(1.61)	(1.40)	(3.49)	(1.62)	(1.47)
Non-ATS OTC share						1.388
						(0.69)
WSB mentions, log						0.036
						(0.87)
Observations	21,105	21,105	21,105	6,942	21,105	19,134
Adjusted R-squared	0.315	0.311	0.315	0.318	0.293	0.299
Sample	All	All	All	Top EEV tercile	All	All
FE	Ticker*Date	Ticker*Date	Ticker*Date	Ticker*Date	Ticker and Date	Ticker and Date
Contract controls	Y	Y	Y	Y	Y	Y
Ticker controls	N	N	N	N	Y	Y

This table reports estimates of (2) in our dividend play sample. SLIM Share and Small Share are the contract-level volume shares of SLIM and small trades, respectively, averaged over two trading weeks before the cum-dividend date. Non-ATS OTC share is the ticker-level share of volume executed in the non-ATS OTC space relative to the total trading volume, averaged over two trading weeks before the cum-dividend date. WSB mentions, log, is the logarithm of total mentions of the ticker on *WallStreetBets* forum. In Panel B, contract controls include: log dollar trading volume, relative spread, IV, moneyness, days to expiry. In Panel A, they additionally include log OI and EEV. Ticker controls include: underlying price, underlying volatility, underlying relative bid-ask spread, underlying market cap. S.E. are clustered by ticker and date. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 16: Arbitrageur activity and retail investor popularity: Retail trading measured over a longer window

	Floor trading share on cum-date				D(floor share > 0)	Floor trading volume, log
	(1)	(2)	(3)	(4)	(5)	(6)
SLIM share	0.051*		0.038	0.057	0.033	0.604**
	(1.82)		(1.45)	(1.21)	(1.22)	(2.57)
Small share		0.338***	0.336***	0.126	0.351***	4.848***
		(6.05)	(6.07)	(1.22)	(6.24)	(8.26)
Observations	21,105	21,105	21,105	6,942	21,105	21,105
Adjusted R-squared	0.404	0.410	0.410	0.473	0.399	0.479
Sample	All	All	All	Top EEV tercile	All	All
Contract controls	Y	Y	Y	Y	Y	Y

This tables reports estimates of (3) in our dividend play sample. SLIM Share and Small Share are the contract-level volume shares of SLIM and small trades, respectively, averaged over two trading weeks before the cum-dividend date. Contract controls include: log OI, EEV, log dollar trading volume, relative spread, IV, moneyness, days to expiry. All regressions include ticker by date fixed effects. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

A.10 Dividend risk and automatic actions of retail brokerages

This appendix presents an example of an automatic action to close short positions exposed to dividend risk on cum-dividend dates undertaken by retail brokerages. The example is from the Terms and Conditions of Robinhood.

Figure 6: Excerpt from Robinhood's Terms and Conditions

Options Dividend Risk

Dividend risk is the risk that you'll get assigned on any short call position (either as part of a covered call or spread) the trading day before the underlying security's ex-dividend date. If this happens, you'll open the ex-date with a short stock position and actually be responsible for paying that dividend yourself. You can potentially avoid this by closing any position that includes a short call option at any time before the end of the regular-hours trading session the day before the ex-date.

Robinhood may take action in your account to close any positions that have dividend risk the day before an ex-dividend date. Generally, we'll only take action if your account wouldn't be able to cover the dividend that would be owed after an assignment. This is done on a best-efforts basis.

A.11 Covariate balance for matching

Figure 7: Covariate balance for SLIM share in Table 7

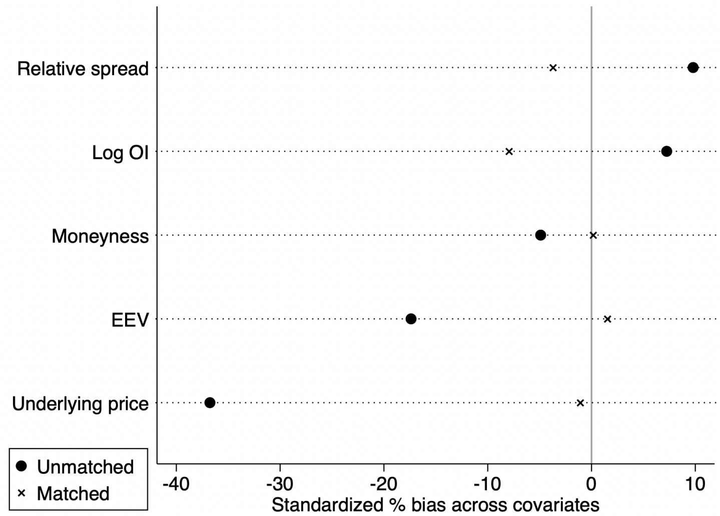
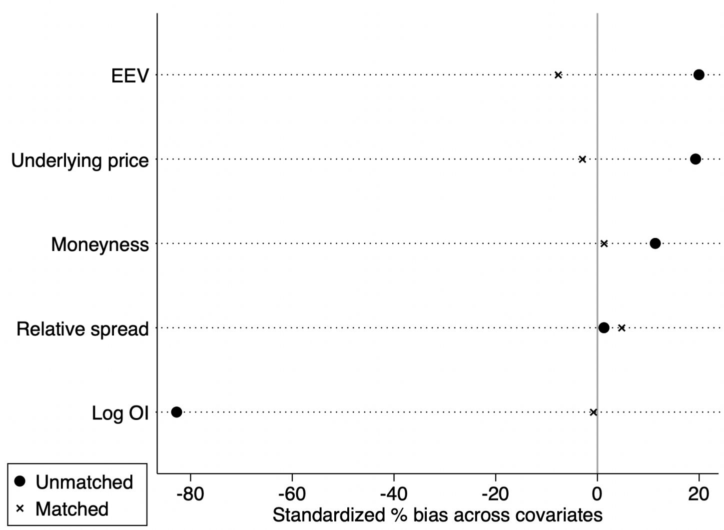
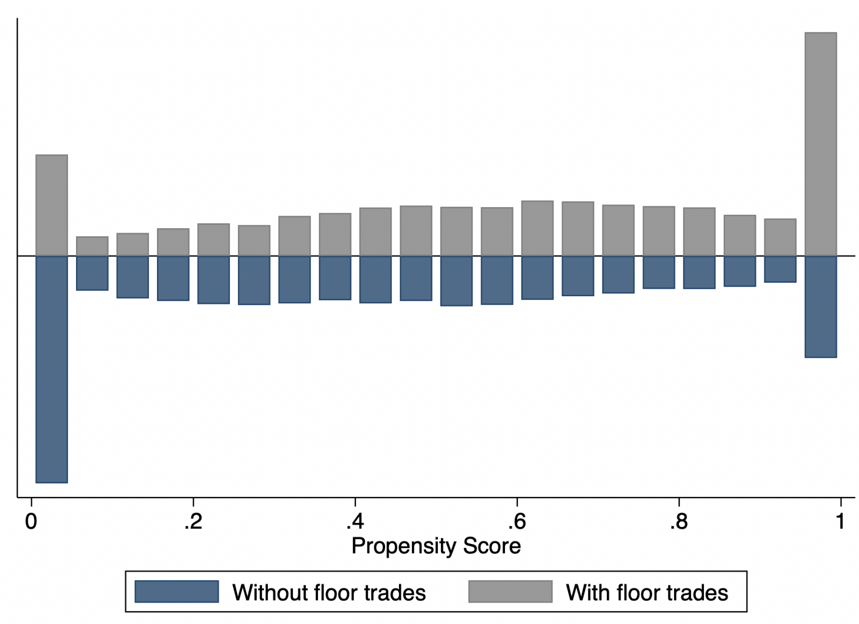


Figure 8: Covariate balance for Small share in Table 7



A.12 Dividend play puzzle in matched contracts

Figure 9: Floor traders' entry across propensity score levels



This figure depicts the number of contracts with and without floor trades across the scores of propensity to have floor trades. The propensity scores are based on the full set of controls: log OI, EEV, log trading volume, relative spread, IV, moneyness, days to expiry, underlying price, underlying volatility, underlying relative bid-ask spread, underlying market cap. We report the balance tests in Appendix A.11.

Figure 10: Covariate balance for Floor share in Figure 9