Trading Volume Shares and Market Quality: Pre- and Post-Zero Commissions

Pankaj K. Jain[1], Suchismita Mishra[2], Shawn O'Donoghue[3], and Le Zhao[4,5]

December 2021

The latest version is available here

Abstract

Major retail brokers that eliminate commissions dramatically increase their market share of client assets. They increasingly routed orders to off-exchange wholesale market makers instead of exchanges to potentially gain more payment for order flow to compensate for commission loss. In the retail brokers' routing trade-off, retail investors end up receiving less price improvement per share. Zero commission traders increase the share of odd lots and smaller order size buckets. Overall market quality surprisingly improves. Effective spreads decline with retail orders placed inside the bid-ask spread. Realized spreads are unchanged but intraday volatility increases suggesting that new orders are relatively uninformed.

JEL: D4, G12, G14, L11

Keywords: Trading volume market share, free stock trading, off-exchange competition, retail trading, short squeeze

[1] Pankaj K. Jain, University of Memphis, Fogelman College of Business and Economics, 3675 Central Avenue, Memphis, TN 38152, pankaj.jain@memphis.edu, 901-678-3810

[2] Suchismita Mishra, Florida International University, College of Business Administration, 11200 S.W. 8th Street RB 204BA, Miami, Florida 33199, mishras@fiu.edu, 305-348-4282

[3] Shawn O'Donoghue, 507 13th Street SE, Unit 1, Washington, DC 20003, shawn.odonoghue@gmail.com, 720-841-9019

[4] Le Zhao, Florida International University, College of Business Administration, 11200 S.W. 8th Street RB 204BA, Miami, Florida 33199, lezhao@fiu.edu, 305-348-2680.

[5] Corresponding Author

For useful comments and suggestions, we thank Gregg Berman, Michael Goldstein, Robert Jennings, Charles M. Jones, Albert "Pete" Kyle, Craig M. Lewis, Phil Mackintosh, Gideon Saar, Ingrid M. Werner. We also thank conference participants including, Alex Kurov, Carole Comerton-Forde, Jay Ritter, Jared Williams, Greg Eaton, and Mark Potter at the University of Memphis, 2021 Eastern Finance Association Conference, 2021 Florida Finance Conference, 2021 Financial Management Association Conference and 2021 Southern Finance Association Conference.

Electronic copy available at: https://ssrn.com/abstract=3741470

Trading Volume Shares and Market Quality: Pre- and Post-Zero Commissions

Abstract

Major retail brokers that eliminate commissions dramatically increase their market share of client assets. They increasingly routed orders to off-exchange wholesale market makers instead of exchanges to potentially gain more payment for order flow to compensate for commission loss. In the retail brokers' routing trade-off, retail investors end up receiving less price improvement per share. Zero commission traders increase the share of odd lots and smaller order size buckets. Overall market quality surprisingly improves. Effective spreads decline with retail orders placed inside the bid-ask spread. Realized spreads are unchanged but intraday volatility increases suggesting that new orders are relatively uninformed.

1. Introduction

The role of secondary market brokerage commissions in equities has been transformed from being the lifeblood of brokerage business (Jennings, 1965) to dropping to zero under competitive pressures in 2019. The restricted and fixed nature of past brokerage commissions had important implications for secondary market information production (Brennan and Hughes, 1991; Brennan and Chordia, 1993). More recently, Goldstein et al. (2009) find that commissions affect institutional trading patterns, and we conjecture that the trade-off between direct commission costs and indirect costs can affect investor's asset choice (Ernst and Spatt, 2021).

The deregulation of brokerage commissions, in combination with the SEC's rules related to the disclosure of order execution and routing practices have reduced commissions and improved order execution quality (Battalio and Loughran 2008; Boehmer, Jennings and Wei, 2007). Cimon's (2021) model of brokers' order routing decisions has not yet been tested and the recent adoption of zero commission by major retail brokers provides us with an opportunity to test its implications. Discount brokers emerged to challenge full-service brokers in the mid-1970s, and more recent

Electronic copy available at: https://ssrn.com/abstract=3741470

technological advancements have further intensified price competition (Bakos et al. 2005).[1] Newer firms, such as Robinhood in 2013 and Webull in 2017, offered app-based trades with low or zero commissions. We track the entire time series of the proportion of retail zero commission brokers. However, a sharper test window became available after Interactive Brokers launched commission-free stock trades through its IBKR Lite pricing program in October 2019 to some retail clients.[2] This action led other major brokers, such as Charles Schwab, TD Ameritrade, E*Trade, and Fidelity to quickly eliminate commissions as well, even though this disruptive strategy meant that many brokerage firms had to eventually merge with others for survival.[3] With zero commissions, retail traders can now quote prices at or within the NBBO and attempt to pick up bid-ask spread as low as a penny, which could not be profitably done in the presence of round-trip commissions which were typically larger than $0.01 per share for retail sized trades. Some critical questions raised by Royal (2019) are: Can brokers afford to drop a source of revenue (i.e., commissions) to zero? Did zero-commission retail brokers capture market share of client assets from commission-charging brokers, given the trade-off between direct versus indirect trading costs, and the potential perception that cost-free trading may be associated with poorer customer service? These questions have gained significance due to the remarkable increase in retail trading in 2020 as more investors find time to trade stocks from home and replace sports gambling with stock trading during the pandemic. Notably, the Congress's GameStop hearing (US House,

[1] Brokerage commissions have declined from May 1, 1975 through present. For details see https://blog.trade.it/2017/02/06/price-wars-online-brokerage-edition/ and https://www.businessinsider.com/historical-trading-commissions-2014-3.

[2] See https://www.interactivebrokers.com/en/index.php?f=45393. Interactive Brokers did not automatically reduce commissions to zero for all retail clients. Therefore, we exclude Interactive Brokers in the main empirical analysis but include it in the robustness tests, where the proportion of retail brokers that offer zero commission encompasses Interactive Brokers. The results are similar whether or not Interactive Brokers is accounted for.

[3] The acquiring firms could offset or subsidize the loss of commission revenue through other sources such as interest on the uninvested cash in client accounts or banking services. See https://www.washingtonpost.com/business/2019/11/25/charles-schwab-will-acquire-td-ameritrade-creating-wealth-management-goliath-with-trillion-assets/.

Electronic copy available at: https://ssrn.com/abstract=3741470

Committee on House Financial Services, 2021) focused attention on retail traders and their brokers. SEC Chairman Gary Gensler suggests that payment for order flow (i.e., PFoF) paid by wholesalers to brokers represents a conflict of interest between retail brokers and their clients and is considering the prohibition of this practice.[4] Therefore, it is essential to examine whether the retail broker order routing practices change for the worse after commissions dropped to zero, given the potential trade-off between payment for order flow received by the retail brokers versus price improvement offered to retail investors for at least a subset of their marketable orders.

Using publicly available data sources, we extend the literature on the role of brokerage commissions to examine changes in volume along three dimensions: between commission versus commission-free brokers, exchanges versus wholesale market makers, and retail odd lot and smaller trades versus larger trades. We examine important theories related to customer attraction to zero commission brokers, broker market share, cost competition, and cream skimming of retail orders, in addition to the impact of zero commission on market quality.

Our first hypothesis focuses on market share of client assets. On one hand, commissions, which are direct costs, may allow brokers to offer larger product offerings, better customer service, and larger new brokerage account promotions. On the other hand, zero commission may be associated with an increase in indirect costs, such as less price improvement received by retail investors.[5] Thus, the impact of zero commission on investors' choice of direct (i.e., paying commissions) versus indirect costs of commission-free trading is important to explore. In fact, we find that investors may prefer to pay trading costs indirectly: Zero (positive) commission brokers dramatically increase (decrease) their market share of client assets. Increased Internet searches for

[4] The interview for Gary Gensler can be found in https://www.barrons.com/articles/sec-chairman-says-banning-payment-for-order-is-on-the-table-51630350595.

[5] Zero commissions may also potentially increase indirect costs associated with trading such as lower interest paid to cash balances and higher margin interest rates charged.

Electronic copy available at: https://ssrn.com/abstract=3741470

the keyword "free stock trading" in Google Trends indicates that retail investors sought out information on zero commission brokers. Furthermore, we also observe that an increase in the number of smaller order size buckets and retail orders and an increase in their dollar volume is associated with the adoption of zero commissions by major brokers. Retail traders can now trade smaller order sizes at lower transaction costs with the commission-free trading.[6]

Our second novel hypothesis focuses on order routing by brokers to non-exchange venues. In the absence of commissions, brokers are not able to directly profit from these newly acquired retail investors' accounts or trades because they are effectively providing nearly free execution services.[7] If retail brokers simply send traders' marketable orders to an exchange, the costs due to the transaction fee paid to the make-take fee exchange could imply negative net profits, unless brokers earn other revenue from clients. As a natural response, brokers may alter their order routing strategy, whereby they can derive some profit by selling the order to wholesale market makers, who compete by making payments for order flow (PFoF) to retail brokers and typically offering retail orders better prices than available from quotes posted on exchanges by providing price improvement.[8] Wholesale market makers also compete for order flow on the dimension of execution quality. Wholesale market makers earn profits from internalizing retail orders, because retail orders do not typically have a relative informational advantage and are small relative to the

[6] For example, a passive trader wishing to purchase 100 shares currently quoting at $10.10 may previously submit a single buy order at $10 to minimize commissions. She can now achieve better execution and the same average price result with a 50-share order at $10.10 and another 50-share order at $9.90 without extra commission costs from two trades.

[7] Brokerages also earn revenue from net interest on funds held in accounts, rehypothecation of stocks held by the firm, borrowing charges for short selling, various account fees (e.g., inactivity fees, account minimum fees etc.), inter-exchange fees from credit and debit cards, payments for money sweeps to banks, and payment for order flow.

[8] According to Citadel Securities quarter 1 2019 retail execution quality statistics reported to the Financial Information Forum, 99.93% of their odd lot market orders executed at the NBBO or better and 96.03% of their market orders received price improvement for S&P 500 stocks. For details see: https://s3.amazonaws.com/citadel-wordpress-prd102/wp-content/uploads/sites/2/2016/09/09175131/FIF-Rule-605-606-WG-CitadelSecurities_Retail-Execution-Quality-Stats_Q1_2019.pdf.

Electronic copy available at: https://ssrn.com/abstract=3741470

average daily volume of a given stock. In addition, wholesale market makers may extract valuable information about sentiment from retail order flow. Formally, we test the hypothesis that under zero commissions, a greater proportion of trading volume is captured by wholesale market makers, because zero commission brokers concentrate on routing orders to wholesale market makers instead of to exchanges.

To test this second hypothesis, we use a difference-in-difference methodology and multivariate regressions to assess the significance of any changes in the execution venue chosen by retail brokers comparing those brokers who drop commissions to zero versus those that do not. Our results suggest that retail brokers who eliminated commissions changed their order routing behavior — their trading volume, which is a function of their routing decisions, shifts from exchanges to wholesale market makers.

Our third hypothesis tests the impact of commissions on several dimensions of market quality from an increase in retail trading volume where we have some expected and some unexpected findings. To begin with, we examine the impact of zero commissions on the amount of price improvement received by retail investors. Zero commissions eliminate a major source of revenue, so retail brokers may increasingly earn revenue from payment for order flow received from wholesale market makers. Wholesale market makers, in contrast, may be indifferent to the split between payment for order flow and price improvement as both represent costs, and retail brokers may prefer to receive more payment for order flow versus providing more price improvement to clients. In equilibrium, wholesale market makers, who pay increased payments for order flow, may widen effective spreads or offer less price improvement per share to maintain their gross profits (Ernst and Spatt, 2021). Thus, it is possible that the amount of price improvement per share offered to retail marketable orders may decline if wholesale market makers make larger

Electronic copy available at: https://ssrn.com/abstract=3741470

payments to retail brokers. Our univariate results are consistent with this hypothesis, which suggests that a statistically significant negative change in amount of price improvement per share for stocks that are popular among retail investors. In other words, it appears that retail investors receive less price improvement per share after zero brokerage commissions are implemented.

We proceed further to examine the impact of zero commissions on additional dimensions of market quality beyond the price improvement aspect above. Mackintosh (2021) reports that retail daily dollar volume increased as early as December 2019 when most retail brokers reduced commissions to zero. We note that with zero commissions, new and existing retail investors can quote limit orders at the bid and ask price or inside the spread more frequently because the order placement strategy is no longer constrained by non-zero commission costs. In addition, market makers can offer narrower quotes because retail orders become smaller permitting market makers to adjust quotes with greater frequency. These strategies unexpectedly result in narrower quoted and effective spreads.[9] As retail investors are typically uninformed (Kumar and Lee, 2006; Foucault et al. 2011; Barber and Odean, 2013), the direction of the stock's trade does not permanently affect the stock's price. As the movement of the quote mid-point is unaffected, realized spreads increase or remain unchanged, and consequently, price impact may fall. Even if the retail order flow is potentially informed (Kaniel, Saar and Titman, 2008; Kelley and Tetlock, 2013; Barrot, Kaniel and Sraer, 2016), the impact of adverse selection is mitigated because wholesale market makers can adjust quotes more frequently as order size decreases. Alternatively, an increase in uninformed retail order flow could magnify fluctuations in price, which may cause market makers to reduce liquidity due to changes in their value of their inventory (Ho and Stoll, 1981).

[9] Larrymore and Murphy (2009) find a rising internalization rates are associated with a decline in the bid-ask spread and variance of the pricing error.

Electronic copy available at: https://ssrn.com/abstract=3741470

Formally, we test our third hypothesis that zero brokerage commissions affect the overall market quality by using the DTAQ data. We conjecture that quoted spread, effective spread and price impact decrease while realized spread increases or remains constant and market microstructure noise increases after the brokerage industry eliminated commissions. We find a significant decrease in percent effective spreads and price impact after zero brokerage commissions came into effect, while realized spread remains unaffected. The decline in effective spread is inconsistent with cream skimming, whereby an increase in uninformed retail orders internalized by wholesale market makers may increase the proportion of informed order that execute on exchange (Easley, Kiefer, and O'Hara, 1996), and is consistent with wholesale market makers serving as cost competitors (Battalio, 1997).

We proxy for retail investors' trading activity by using Robintrack data and specifically examine the effect of zero commission on stocks popular with retail investors. Robintrack data (https://robintrack.net) has been used in recent studies to proxy for retail investor's activities. For instance, a complementary working paper by Eaton et al. (2021) used Robintrack to examine the effect of retail trading on financial markets when Robinhood has a platform outage. Our study is different from Eaton et al. (2021) in several dimensions. First, we examine changes in routing behavior for all brokers who switched from a positive to zero commission in October 2019. In addition, our sample focuses on the adoption of zero commissions by all major brokers in the fall of 2019, which is a fundamentally different regime shift than outages of a single broker. In contrast, Eaton et al. (2021) focus on changes in stock ownership by Robinhood clients and Robinhood's platform outages that took place in 2020. We do not expect any changes in Robinhood's routing behavior, because Robinhood has offered commission-free trades since March 2015. We separately track the entire time series of the proportion of retail zero commission brokers. Second,

Electronic copy available at: https://ssrn.com/abstract=3741470

we use SEC Rule 605 reports filed by exchanges and wholesale market makers to examine aggregated order execution quality and SEC Rule 606 reports from retail brokers to examine previously untested hypotheses on order routing changes, while Eaton et al. (2021) mainly focus on examining market quality by using trade-level data in DTAQ.

To the best of our knowledge, we are the first to examine the distribution of volume between commission versus commission-free brokers, exchanges versus wholesale market makers, and retail odd lot and smaller trades versus larger trades. This empirical analysis tests important theories related to market share as well as whether wholesale market makers behave either as cost competitors or cream skimmers of retail orders. We use multiple datasets to examine the impact of zero commissions as each dataset has its own unique advantages. The 605 reports provide execution quality metrics for each security by execution venue at monthly frequency. The 606 reports disclose order routing practices by brokers, at monthly frequency. The reports are released each quarter. DTAQ provides trade level data inclusive of odd-lots at the individual security level. Robintrack statistics allow us to focus on stocks heavily traded by retail investors. FINRA's transparency data allows us to examine volume by wholesaler market maker. Thus, the combination of datasets helps us to fully understand the impact of zero commissions on retail participation, broker routing, and market quality.

The remainder of the paper is organized as follows. Section 2 develops our hypotheses on the relationship between zero- commissions, order routing choices, and market quality. Section 3 describes data sources. Section 4 reports our main empirical results and robustness tests and Section 5 concludes the paper. Additional information is provided in Appendix A and B and the Internet Appendix.

Electronic copy available at: https://ssrn.com/abstract=3741470

2. Hypothesis Development

We test three main hypotheses related to how zero commissions affect broker order routing decisions and market quality. The most important impact of the elimination of commissions may be on a broker's market share of retail clients. We empirically test whether retail brokers that eliminate commissions attract client assets in accordance with Bell, Keeney, and Little's (1975) market share theorem. If some retail brokers adopt zero commissions, while other brokers maintain positive commissions, there may be a considerable shift in the market share of the retail investors' assets from the positive to zero commission brokers or vice versa. The shift may occur in either direction because non-zero commissions may allow brokers to offer larger product offerings, better customer service, larger new account promotions, higher cash balance interest, and more price improvement. Alternatively, eliminating commissions may be preferred by retail investors as it reduces the direct cost of trading. In this scenario, how do retail customers choose a broker considering this trade-off between direct and indirect costs and the potential perception that cost-free trading may be associated with worse customer service? Decision-making may follow referent thinking where people compare the benefits and costs for each option and chose the option that should provide the highest benefit for any level of cost.[10] However, Shampanier et al. (2007) suggest a "zero-price" effect in decision making, which is the human cognitive bias to overvalue the "free" component in the products. In other words, a product or service with a "free" promotion is extraordinarily attractive to individuals.

Therefore, we conjecture that retail investors may use referent thinking or act under zero-price psychological influences (Shampanier et al, 2007) in choosing a brokerage. With positive commissions the referent thinking effect dominates the decision in choosing the broker. Retail

[10] See Payne et al. (1991) and Simonson and Tversky (1991). Referent thinking, such as the comparison between risk and return, are widely applied in portfolio optimization in finance.

Electronic copy available at: https://ssrn.com/abstract=3741470

investors evaluate brokers by comparing the estimated benefits they may receive along with costs. However, after most retail brokers announced and implemented zero-commissions in October 2019, advertising it as "free-trading", the zero-price effects dominate the retail investor's decision-making process. We conjecture that retail investors overvalue the "free-trading" component and ignore the potential cost.

Brokers that charge zero-commissions may also increasingly compete for customers based on the digital experience provided by their trading platforms. In addition, retail investors who made frequent trades due to flexible work schedules during the COVID pandemic and are now accustomed to zero commissions may find brokers charging zero commissions more attractive than the positive commission brokers.

In addition, orders submitted by retail investors are typically uninformed (Kumar and Lee, 2006; Foucault et al., 2011; Barber and Odean, 2013), and generally have smaller size than orders submitted by institutional investors (Barber et al., 2008). As retail investors no longer need to consolidate their trades to save on commissions, the size of retail orders may decline. Therefore, brokers may receive more uninformed orders that are of smaller size after eliminating commissions.

H1: Zero-commission brokers gain more retail clients and the volume of small retail trade size increases.

One consequence of zero commissions is that brokers are no longer able to directly earn revenue from a retail investor's commission and are effectively providing nearly free execution

Electronic copy available at: https://ssrn.com/abstract=3741470

services.[11] If retail brokers simply send investors' marketable orders to a traditional make-take exchange, the costs due to the transaction fee paid to the exchange could imply negative net revenue (O'Donoghue, 2021). Battalio, Jennings and Selway (2001), Parlour and Rajan (2003), and Fox, Glosten and Rauterberg (2019) suggest that selling orders for payment for order flow (PFoF) helps broker achieve lower commissions. A theoretical model in Cimon (2021) also predicts that the size of commissions drives broker routing behavior. Thus, to offset revenue losses associated with zero commissions, brokers may alter their order routing strategy, where they may derive some revenue by selling more orders to wholesale market makers in exchange for PFoF. Thus, wholesaler market maker, who offer PFoF, may become the preferred destination for retail brokers after commissions drop to zero instead of exchanges, who do not offer PFoF.[12]

Why is payment for order flow profitable? For retail brokers, payment for order flow is revenue as a function of the number of shares sold to a wholesale market maker. Retail investors are generally considered to be uninformed and do not have a relative informational advantage relative to institutional investors (Chung et al., 2006; Kumar and Lee, 2006; Foucault et al. 2011; Barber and Odean, 2013). Wholesale market makers pay for retail order flow to minimize adverse selection costs, because it is uniformed. Orders from retail investors are also smaller relative to institutional orders. Thus, the risk from being a counterparty to retail orders is much smaller due to their relatively smaller order size and limited information content.

Easley, Kiefer, and O'Hara (1996) argue that wholesale market makers cream skim uninformed retail orders to earn the half bid-ask spread less their nominal cost of paying for the

[11] Brokerages also earn revenue from net interest on funds held in accounts, rehypothecation of stocks held by the firm, borrowing charges for short selling, various account fees (e.g., inactivity fees, account minimum fees etc.), inter-exchange fees from credit and debit cards, payments for money sweeps to banks, and payment for order flow.
[12] Retail brokers may still have somewhat reduced incentive to route orders to exchanges which pay relatively higher make rebates as suggested by Battalio et al. (2016).

Electronic copy available at: https://ssrn.com/abstract=3741470

flow and any price improvement. As more uninformed order flow is routed off-exchange, the proportion of informed orders executed on exchange increases causing bid-ask spreads to increase. Battalio (1997), however, argues that an increase in orders executed by wholesale market makers can lead to narrower bid-ask spreads when wholesale market makers serve as cost competitors to those posting quotes on exchange.

Wholesale market makers also trade against retail orders to enter or exit their market making positions, which, in turn, increases liquidity. Furthermore, these wholesale market makers may use retail order flow as part of hedging strategies across different asset classes. Once the wholesale market maker purchases uninformed retail order flow they internalize 100% of it instead of sending these orders to exchanges. This choice has direct implications for the market share captured by trading venues. Formally, we test the hypothesis that total trading volume increases for off-exchange wholesale market makers.

H2: After the adoption of zero commission by leading retail brokers, order routing to off-exchange venues increases and trading volume subsequently increases off-exchange.

The third important impact of commissions are the changes in market quality associated with changes in proportion of investors that are retail. Several welfare implications of relative ease of retail trading are highlighted by Heimer and Simsek (2019) in the context of leveraged retail forex trading including the specific concern that excessive trading volume that does not necessarily benefit market participants, but enriches the institutions that intermediate those trades. Zero commissions eliminate a major source of revenue, so retail brokers may increasingly earn revenue from payment for order flow received from wholesale market makers. Wholesale market makers,

Electronic copy available at: https://ssrn.com/abstract=3741470

in contrast, may be indifferent to the split between payment for order flow and price improvement as both represent costs, and retail brokers may prefer to receive more payment for order flow versus providing more price improvement to clients. In equilibrium, wholesale market makers, who pay increased PFoF, may offer less price improvement per share to maintain their gross profits (Ernst and Spatt, 2021). Thus, it is possible that the amount of price improvement per share offered to retail marketable orders may decline if wholesale market makers make larger payments to retail brokers. A decline in price improvement represents an increase in indirect costs to retail investors.

We further proceed to examine other dimensions of market quality such as effective spread, realized spread and price impact. On the one hand, the decline in the direct commission revenue may indirectly cause effective spreads to widen, should wholesale market makers offset a loss of revenue if payment of order flow increases. On the other hand, under zero commissions retail investors can more easily place orders at or within the bid and ask prices more frequently, because a non-zero commission no longer constrains the price of quotes.[13] In addition, market makers can adjust quoted prices more frequently when retail trade sizes decline. This strategy results in a narrower effective spread as suggested by Bartlett, McCrary and O'Hara. (2021).

Retail investors are assumed to be uninformed in many theoretical models and many empirical studies find that orders placed by retail investors introduce more noise to the market. [14] Hence, stock intraday volatility (noise) may increase after a sharp increase in uninformed retail trading associated with zero commissions. Furthermore, because retail investors are typically

[13] For example, if an investor saves $50 a day and commissions are $8. Previously the investor will likely wait to accumulate $5,000 to buy 100 shares of stock quoting at a current bid of $50.00 and an ask of $50.05 by posting a limit buy at $50.01. With non-zero commissions they provide liquidity only once in 3 months because buying 1 share per day deeply cuts into returns. In contrast, with zero commissions, the investor can place a 1 share order every single day inside the bid-ask spread. In addition, after the initial purchase, the investor may post a limit sell at $50.04 with the hope of buying it back at $50.01 again. Such an investor may do this multiple times each day. This is strategy is profitable with a commission-free trades but not with a $8 commission per trade.

[14] See Black (1986); Shleifer and Summers (1990); De Long et al. (1990); Stambaugh (2014); Kumar and Lee 2006; Kurov 2008; Foucault et al. 2011

Electronic copy available at: https://ssrn.com/abstract=3741470

uninformed, the direction of a stock's trade does not increase the informativeness of that stock's price. As more retail orders enter the market after zero commissions are adopted and retail order size declines, price impact should fall because the overall flow is less informed and market makers can adjust their quotes more often. Thus, the realized spreads should increase or remain unchanged. More specifically, under zero commissions, the quoted spread, effective spread and price impact may decrease while (microstructure) noise and the realized spread may increase or remain constant depending on the degree of competition among liquidity suppliers.

H3: Under zero commissions and increased uninformed retail participation, market quality changes. Price improvement per share offered to retail investors is less. Quoted spread, effective spread, and price impact decrease while volatility (noise) and realized spread increase or remain constant.

3. Data Sources and Description

Zero commission adoption announcements are collected from brokerage websites and the timestamps for such announcements are from their official twitter accounts. The data for the quarterly net change in client assets are collected and calculated from retail brokers' 10-Q reports. FINRA's transparency data allows us to examine volume by wholesaler market maker. We also use the NYSE Daily Trade and Quote (DTAQ) database, SEC Rules 605 and 606 public disclosure reports of order execution and routing practices, CRSP, and VIX volatility index from CBOE. [15] We also download Short Interest from Compustat's supplemental files, because the media has

[15] SEC Rule 605 and 606 were formerly named as SEC Rules 11Ac1-5 and 11Ac1-6, respectively.

Electronic copy available at: https://ssrn.com/abstract=3741470

reported that retail investor trading may have been involved in a possible short squeeze in GameStop.[16]

The DTAQ trade file contains detailed information about every trade, such as the stock symbol, time stamp, trade price, share volume, execution venue (including exchanges and off-exchange), and trade condition. The DTAQ quote file and NBBO file contains detailed information about each quote such as the time stamp, stock symbol, or exchange(s) where quotes are posted, bid and ask price, size, best bid or offer indicators and various other quote conditions. Holden and Jacobsen (2014) provide the institutional details that go behind the creation of the DTAQ dataset and its relative advantages over other datasets.

We use the SEC Rule 605 to analyze changes in order execution for market makers. Rule 605 requires market centers to make publicly available standardized, monthly reports of statistical information concerning their order executions categorized by security, order type, and order size. Information includes number of covered orders, shares, execution speed, realized spreads, effective spreads, and price improvement.

We use the SEC Rule 606 reports to evaluate changes in order routing behavior for brokers who introduced zero commission versus those who continue to charge positive commissions. The data in the SEC Rule 606 reports are provided on a quarterly frequency. Each broker or dealer disclosures its routing in NMS stocks by the percentage of their orders that are non-directed and are market, limit, or other order types. It also requires brokers to provide the percentage of each order type that is routed to each of their top ten routing destinations and any other venue receiving at least five percent of their non-directed orders. The reports also contain a discussion of some aspects of a broker's relationship with each venue, including payment for order flow. We manually

[16] https://www.sec.gov/files/staff-report-equity-options-market-struction-conditions-early-2021.pdf.

Electronic copy available at: https://ssrn.com/abstract=3741470

collect the Q3-2019 and Q4-2019 Rule 606 reports for retail brokers and calculate the changes in broker's routing to each venue by order type. Additional information on Rules 605 and 606 can be found on the SEC website.[17]

Control variables, such as the Amihud illiquidity measure (Amihud 2002), daily volume, price and volatility are derived from CRSP, and VIX volatility index is sourced from CBOE.

For the sharpest test of the impact of zero commissions, our sample from June 2019 to February 2020 surrounds the adoption of zero commission by major retail brokers, such as Ally Invest, Charles Schwab, E*Trade, Fidelity, Raymond James, and TD Ameritrade between October 3, 2019 and October 21, 2019. We also conduct matched-months pre- and post-sample period robustness tests in the internet Appendix. Separately, we also analyze the impact of zero commissions by constructing a continuous time series variable tracking the proportion zero commission brokers in the retail trading services industry.

Our sample includes all stocks with average of daily closing price above $2.00 during regular trading hours (9:30 am - 4:00 pm). From Robintrack data (https://robintrack.net) we create a list of the top 100 most popular stocks among retail investors by counting the average number of Robinhood users that hold a particular stock on a given day.

We identified the wholesale market makers and exchanges to which retail brokers route orders using the SEC Rule 606 reports that retail brokers make publicly available.[18] Table 1 Panel A lists the wholesale market makers and their payments for receiving orders. Table 1 Panel B lists

[17] https://www.sec.gov/divisions/marketreg/disclosure.htm

[18] The wholesale market makers described in the SEC Rule 606 reports are Citadel, G1X (i.e., Susquehanna), Two Sigma, UBS, and Virtu. The Financial Times identifies these same firms as the largest retail market makers by volume: https://www.ft.com/content/4a439398-88ab-442a-9927-e743a3ff609b. Our study focuses on the equity markets, so we do not include market makers for options such as Global Execution Brokers.
The stock exchanges to which retail brokers that charge zero commissions route are NYSE Arca, NYSE, Nasdaq and EDGX. Nasdaq changed its interpretation of SEC Rule 605 in September 2019, which affected the data contained in its reports. Consequently, SEC Rule 605 data for Nasdaq is different before versus after September 2019; therefore, we exclude Nasdaq's SEC Rule 605 reports from our analysis.

Electronic copy available at: https://ssrn.com/abstract=3741470

the retail brokers that charge and do not charge commissions. The payments paid by wholesale market makers are collected from the publicly available SEC Rule 606 reports, and the commissions are from each broker's public website. We follow Boehmer et al. (2021) to infer retail trading from intra-day trades as only retail marketable orders may receive price improvement.

****

Add Table 1 about here

****

4. Results

4.1 New Client Acquisition by Zero Brokerage Commission Brokerages

First, we use retail brokers' 10Q reports from Q4-2018 to Q1-2021 to examine the change in market share of retail investors' assets. In each quarter, we calculate the net percent change in the broker's client assets. The results are presented in Figure 1. Figure 1(a) presents the net change in client assets in each quarter for retail brokers. The blue solid line represents the net change in client assets for retail brokers that announced zero commissions, and the red dashed line is for retail brokers that charge non-zero commissions. The grey vertical line is the October 2019 event time when the major retail brokers announced zero commissions. The retail brokers that announced zero commissions in October 2019 used in our analysis are Ally Invest, Charles Schwab, E*Trade, Fidelity, Raymond James, and TD Ameritrade. The retail brokers with non-zero commissions as of April 1, 2020 for whom we could locate order routing information are BB&T Securities LLC, Citi Group, Edward Jones, LPL Financial, Morgan Stanley, Muriel Siebert, Stifel, and Zacks Trade. As the trends are similar before the zero-commission event, we infer that the two categories

Electronic copy available at: https://ssrn.com/abstract=3741470

of brokers are similar. Brokers that reduced commissions to zero and those that continued to charge commissions, both lost clients, were nearly flat, and then gained client assets, respectively, in the three quarters leading up to the announcement. Thus, the choice of zero commission is an exogenous shock with respect to market share of client assets. The non-zero commission brokers can be used as a good control group. After the fourth quarter of 2019, when the major retail brokers introduced zero-commission trades, the net change in client assets changed dramatically in the following quarter. Despite the increase in retail stock trading activity,[19] retail brokers who continued to charge non-zero commissions reported a 9% loss in client assets. In contrast, zero commission brokers saw the net new investor asset acquisitions grow by 7%, for a net difference between brokers charging zero and non-zero commissions of 16%. The large difference in the net change in client assets suggests that commissions are an important factor for retail investors when choosing a broker. Media also reported an immediate surge in retail customer accounts at zero commission brokers.[20] Additionally, zero-commission brokers may have attracted first-time retail investors in the first quarter of 2020 during the COVID-19 quarantine, and existing retail investors may have moved assets from brokers that charge a non-zero commission to those that charge no commission. Additionally, we exploit the variation in commission reduction across brokers in our sample. Figure 1(b) compares the percentage reduction in commissions with the percentage change in their client assets after the zero-commission event. The bars represent the absolute reduction in the commission per trade by each broker and the line represents the average client assets growth rate by broker after zero commission event. Figure 1(b) suggests a positive relation between the magnitudes of commission reduction and increases in client assets.

[19] Bloomberg reports an increase in retail trader volume: https://www.bloomberg.com/news/articles/2020-02-21/free-stock-trades-are-stirring-an-epic-mom-and-pop-buying-frenzy.
[20] https://www.barrons.com/articles/tda-raymond-james-and-zero-commissions-51571852744.

Electronic copy available at: https://ssrn.com/abstract=3741470

****

Add Figure 1 about here

****

To confirm that commission-free trading is an important factor in driving the growth of client assets of zero commission brokers, we next examine search interest for "free stock trading" in Google Trends. Figure 2 shows the weekly nationwide search popularity of keywords "Free Stock Trading" from 06/2019 - 06/2020 in Google Trends. At the beginning of October 2019, when several major retail brokers announced the implementation of zero commissions, the search volume of keywords "Free Stock Trading" increased. Furthermore, the popularity of "Free Stock Trading" reaches its peak at the end of March 2020, when the nationwide lockdown policies started, and search volume increased again in the mid-April 2020, when stimulus checks from the IRS are deposited. The changes in "Free Stock Trading" searches suggest that brokerage commissions are an important factor for retail investors in searching and choosing online brokers. Overall, Figure 2 along with findings in Figure 1 are consistent with Hypothesis 1. We show that investors are attracted by “free” trading and retail brokers who adopt zero commission policy gain client market share, suggesting the zero-price effects dominate the investor’s decision-making procedure when choosing a broker.

****

Add Figure 2 about here

****

Electronic copy available at: https://ssrn.com/abstract=3741470

Next, we examine changes in retail orders from trade sizes. Table 2 reports the difference-in-difference results for the average change in the number of shares executed by order size bucket and order type from SEC Rule 605 reports, which allows us to examine changes in trade sizes routed to wholesale market maker. As predicted, the number of shares executed increased across all size buckets for wholesale market makers after zero-commissions are implemented. Moreover, the percentage difference between the smallest order size bucket (100-1,999) and largest order size bucket (2,000-5000+) is positive and statistically significant. This increase is consistent with the hypothesis that retail investors may have submitted more orders of smaller size after the zero-commission event. Consequently, the wholesale market makers may receive more shares of covered orders in the 100-1,999 share small size bucket relative to larger share size buckets.

****

Add Table 2 about here

****

While our difference-in-difference test in Table 2 supports our hypothesis that number of smaller orders executed increases after zero commissions are adopted, we now focus on a multivariate analysis to control for other explanatory variables. Table 3 presents results from the following OLS regression:

$$VolumeShare_{i,t} = \alpha + \beta_1 ZCEvent\ Dummy + \beta_2 RetailPop_i + \beta_3 ZeroCommission \times RetailPop_i + \beta_4 Volatility_{i,t} + \beta_5 VIX_t + \beta_6 \log(MktCap)_{i,t} + \beta_7 InvPrice_{i,t} + \beta_7 Effective\ Spread_{i,t} + \epsilon_{i,t} \quad (1)$$

Electronic copy available at: https://ssrn.com/abstract=3741470

To address the potential endogeneity concern, we also test the following regression with lagged controls:

$$VolumeShare_{i,t} = \alpha + \beta_1 ZCEvent\ Dummy + \beta_2 RetailPop_i + \beta_3 ZeroCommission \times RetailPop_i + \beta_4 Volatility_{i,t-1} + \beta_5 VIX_{t-1} + \beta_6 \log(MktCap)_{i,t-1} + \beta_7 InvPrice_{i,t-1} + \beta_8 Effective\ Spread_{i,t-1} + \epsilon_{i,t} \quad (2)$$

The dependent variable, $VolumeShare_{i,t}$, is the proportion of shares executed for stock i in month t in the smaller order size buckets of less than 1,999 shares divided by the total shares executed in all order size buckets, and *ZCEvent Dummy* is a dummy variable that equals one if the observation is after the zero commission event month and zero otherwise. $RetailPop_{i,t}$ is a dummy variable equal to 1 if the stock i is one of the top 100 stocks held by Robinhood users in month t. In addition, we control for market volatility, using *VIX* (Comerton-Forde et al. 2018). At the stock level we control for firm size using the natural log of market capitalization, *log(MktCap*), stock's return variance, *Volatility,* mean closing price, *Price*, and mean effective spread, *EffectiveSpread* (Hendershott and Moulton, 2011; Malinova and Park, 2015; Stoll, 2000). The dataset is an unbalanced panel as it contains eight months and 6,767 stocks. Therefore, we cluster by time to minimize the number of uncorrelated observations (Petersen, 2009; Thompson, 2011). Each regression includes time fixed effects, which absorbs common shocks that are stock invariant.

The equation (1) in Table 3 reports coefficients under contemporaneous control variables, and equation (2) reports the lagged control variables. The coefficient on *ZCEvent Dummy* is positively and statistically significant at the 1% level. This result suggests that the implementation of the zero commission relatively increases volume for order size buckets containing 100 – 1,999 shares relatively more than other larger order size buckets. Moreover, the interaction of the ZCEvent Dummy and retail popular stock dummy is positive and statistically significant, which suggests that the proportion of smaller orders may increase more for stocks that are popular among

Electronic copy available at: https://ssrn.com/abstract=3741470

retail investors. The coefficient on the retail popular stock dummy is negative, suggesting that retail popular stocks are also popular among institutional traders and in general have relatively more executed orders in size buckets greater than 1,999 shares. Overall, we find that retail investors may submit smaller size orders, as more shares are executed in the smaller order size buckets, when commissions fall to zero.

****

Add Table 3 about here

****

In addition, we examine the odd lot volume executed off-exchange from DTAQ data to test whether our results in Table 3 are robust. DTAQ dataset provides more frequent intra-day data at security level, and it contains the trading size and price for each transaction. In today's market, nearly half of all trades are in odd lots size.[21] The intuition is that, before commissions dropped to zero, retail traders may sub-optimally combine orders into a single large order when they pay a fixed commission per trade. As commissions fall to zero, retail traders may place many more odd lot sized orders to execute their optimal trading strategy. The findings are presented in Table 4. Panel A shows overall changes in volume by trade size bucket as reported by all off-exchange venues and Panel B shows changes in retail trading volume by size bucket in off-exchange venues where we identified marketable retail orders that received price improvement based on method proposed by Boehmer et al. (2021). As we hypothesized, odd lot trade size executions increased

[21] The Wall Street Journal reports that odd lot trades increased: https://www.wsj.com/articles/tiny-odd lot-trades-reach-record-share-of-u-s-stock-market-11571745600.

Electronic copy available at: https://ssrn.com/abstract=3741470

relative to larger trade sizes by more than 60% for all off-exchange venues (in Panel A) and marketable retail order executions that received price improvement (in Panel B) after commissions dropped to zero. The percentage difference between the smaller (1-1,999 shares) and larger (2,000-5000+ shares) trade size buckets (2,000-5000+ shares) is positive and statistically significant in both Panel A and Panel B. Overall results from DTAQ data are consistent with our hypothesis that retail investors placed more smaller size orders after commissions drop to zero.

To further understand the economic significance of the change in the odd lot and small trade sizes, we divide the trading volume in each trade-size bucket by the total trading volume in all size buckets to first compute the market share of each trade size bucket in Panel C. Additionally, we display Panel C results in Figure 3. Comparing the changes across size buckets our analysis reveals small trade sizes capture a bigger share of total trading after the adoption of zero commissions. For example, the percentage of volume in trade sizes below 499 shares executed off-exchange by all venues increased by 3.52% including odd lots (1.47% + 2.05%). Moreover, if we only count the marketable retail volume executed by wholesale market makers that is identified by Boehmer et al.'s (2021) method, the proportion of trading size below 499 shares increased even more by 4.83%. In summary, these results are consistent with our first hypothesis that zero commissions are associated with a significantly higher market share of client assets and a larger fraction of odd lot and small trade size volume relative to larger trade size buckets. This suggests retail investors may prefer to pay indirect costs, such as reduced price improvement, instead of direct costs (i.e., commissions) for brokerage services.

****

Add Table 4 about here

Electronic copy available at: https://ssrn.com/abstract=3741470

****

****

Add Figure 3 about here

****

4.2 Association between Zero-Commissions and Order Routing Decisions

To test the impact of zero commissions on retail broker routing decisions, we use SEC Rule 606 quarterly reports. Table 5 presents difference-in-difference results for the average change in the percent of orders routed to wholesale market makers or exchanges weighted by the number of retail brokers for order type before versus after the adoption of zero commission by major brokers in October 2019. We first present the average difference in percent of orders routed for execution weighted by the number of retail brokers before versus after the zero-commission event in the fall of 2019 for the zero commission brokers using each broker's SEC Rule 606 Q3 and Q4 2019 reports. Then we present the average difference for the control group of brokers that still charge non-zero commissions. For example, the percent of market orders routed to wholesale markets increased by 0.36% and decreased by -0.74% on average by brokers that eliminated and continued to charge commissions, respectively. The second to last column has the difference-in-difference of the average percent of orders routed for execution between those brokers that eliminated commissions and those that did not. In particular, the difference-in-difference is 1.10% for market orders on average and statistically significant. Thus, we conclude that retail brokers that eliminated commissions increasingly routed market orders to wholesale markets makers relative to those brokers that charged commissions. These results also hold for non-directed orders in

Electronic copy available at: https://ssrn.com/abstract=3741470

general and limit and other orders in particular. This is displayed in Figure 4(a). Conversely, for the exchanges, the difference-in-difference is negative and statistically significant for non-directed orders in general and market and limit orders in particular which implies that zero commission brokers routed a smaller percent of orders on average to exchanges relative to brokers that charged commissions. This is displayed in Figure 4(b).

****

Add Table 5 about here

****

****

Add Figure 4 about here

****

Table 6 presents regressions of the change in the percent of orders (by type) routed to either a wholesale market maker or exchange on a zero-commission broker dummy (ZCBroker Dummy), controlling for broker and listing exchange fixed effects. The ZCBroker Dummy equals one for retail brokers who announced zero-commissions in October 2019 and equals zero for retail brokers charging positive commissions as of April 1, 2020. We calculate the change in the percent of orders routed by brokers from Q3 2019 to Q4 2019 for wholesale market makers and exchanges from the SEC Rule 606 reports provided by retail brokers.[22] Panel A and B shows the change in the percent

[22] SEC Rule 606 reports contain aggregated order level statistics across stocks.

Electronic copy available at: https://ssrn.com/abstract=3741470

of orders (by type) routed to either a wholesale market maker or exchange, respectively. The coefficient on ZCBroker Dummy in Panel A is positive and statistically significant at the 5% level for non-directed and market orders and in Panel B is negative and statistically significant at 1% level for limit orders and at 5% level for non-directed orders. These results suggest those retail brokers that adopted zero commissions increasingly routed more orders to wholesale market makers relative to retail brokers that charge commissions. In summary, the results in Table 6 support hypothesis 2 that the adoption of zero commissions affected retail brokers' order routing decisions as orders were increasingly routed to wholesale market makers, allowing brokers to earn more payment for order flow.

****

Add Table 6 about here

****

Next, we test whether the changes in the broker's routing choices associated with zero commissions affect the distribution of trading volume market share between wholesaler market makers and exchanges. We showed previously that zero commissions are associated with increased retail trading. If zero commission brokers route more order flow to wholesale market makers, the market share of total volume should increase for off-exchanges wholesaler market makers relative to exchanges. To illustrate our findings, we use FINRA transparency and CBOE data to examine volume by national exchange groups and specific wholesaler market makers. We calculate market

Electronic copy available at: https://ssrn.com/abstract=3741470

share of volume by venue before versus after zero brokerage commissions are implemented.[23] The result is presented in Figure 5 Panel A. It clearly illustrates that market share of volume significantly increases for wholesale market makers and decreases for exchanges after the adoption of zero commissions. Figure 5 Panel B shows the market share of volume for all exchange groups dropped while the wholesale market makers' market share generally increased. Citadel, G1X, Two Sigma, UBS, and Virtu are the top five largest wholesale market makers by volume and gained additional volume. Furthermore, Citadel and Virtu's combined volume in December 2020 accounts for more market volume than NYSE Group.[24] In summary, Figure 5 supports hypothesis 2, which suggests that after zero commissions became common, retail brokers routed orders more intensely to wholesale market makers. Consequently, wholesale market makers volume increases relative to that of exchanges.

****

Add Figure 5 about here

****

We formally test the second hypothesis that volume increases off-exchange and decreases at exchanges using multivariate regression analysis in Table 7.[25] We use DTAQ data to identify the proportion of the trading volume that executes off-exchange (code as "D" in dataset). Table 7 reports coefficient estimates for OLS regressions where off-exchange venues' percentage of

[23] Figure 5 shows the market shares for the top seven wholesale market makers.
[24] https://qz.com/1969196/citadel-securities-gets-almost-as-much-trading-volume-as-nasdaq/.
[25] The univariate test for a change in the market share of volume by venue type is presented in the online appendix. https://docs.google.com/document/d/e/2PACX-1vSxcadtY3k7eYMxtMJS7X2uSwfffPGfRSgCEwsoiyITFc02i-OeBgfTiYXPZ44wBEkwcMBOCFVPzZlS/pub

Electronic copy available at: https://ssrn.com/abstract=3741470

market share of trading volume in the period is the dependent variable, the adoption of zero commissions, *ZCEvent Dummy*, is the key explanatory variables, and various control variables are included based on prior literature. We consider total off-exchange share of volume for all order types and any type of investor in columns (1) and (2). Total off-exchange volume share includes executions by Alternative Trading Systems (ATSs), wholesale market makers that internalize retail orders, and over-the-counter (OTC) non-ATS trades that are not internalized retail orders. Columns (3) and (4) are regressions where the dependent variable is the percentage of retail volume executed by wholesale market makers that is limited to marketable orders that received price improvement. Boehmer et al. (2021) identify retail trades as those reported to the FINRA TRF as marketable orders that receive price improvement and are executed off-exchange.[26] These retail trades do not include institutional orders, marketable retail orders that executed at the national best bid or offer, worse prices, or the midpoint, or any non-marketable limit orders submitted by retail investors.

All control variables are described in Appendix A. We use the lag(spread) to control for the ex-ante illiquidity and Amihud illiquidity measure to capture the ex-post price impact at the daily level given total volume. T-statistics are reported in parentheses and are based on standard errors clustered at the date and stock level. Column (2) of Table 7 confirms that stocks with higher volume, smaller market capitalization, and lower prices have more off-exchange trading. The positive coefficient for the ZCEvent Dummy variable is consistent with our hypothesis and suggests that off-exchange venues increase their share of volume after major brokerage firms

[26] Price improvement from wholesale market makers is not required but is commonly provided to marketable limit and market orders. Our regressions using Boehmer et al.'s (2021) method to identify retail orders only include retail marketable orders that receive price improvement and no marketable orders that execute at the midpoint, NBBO, or outside the NBBO or any non-marketable limit orders. Therefore, the regressions using Boehmer et al.'s (2021) method have a smaller coefficient than those using total TRF volume.

Electronic copy available at: https://ssrn.com/abstract=3741470

eliminate commissions. More importantly, the coefficient of ZCEvent Dummy is not only statistically significant, but also economically significant. The share of volume for off-exchange venues increased by 1.685%, which equals an increase of an average of 13,533 shares per stock and day for off-exchange volumes, or approximately an increase in 94 million shares across all stocks in off-exchange volume per day.[27] Furthermore, the volume share of marketable retail orders executed by wholesale market makers that receive price improvement increased 0.485% and is statistically significant at the 5% level.[28] In summary, the results are consistent with our second hypothesis that brokers increasingly routed more orders to wholesale market makers and relatively fewer to exchanges.

****

Add Table 7 about here

****

Furthermore, to assess the long-lasting impact of zero commissions, we use the proportion of retail brokers that offer zero commission trading, *ZCBroker proportion*, as the independent variable as a robust test for our findings in Table 7. Although most zero commission policies were announced and adopted in October 2019, some brokers switched to zero commissions in a later period and others launched themselves as zero commission brokers from their founding date.[29] The proportion of zero commission brokers is a continuous variable, which allows us to include all brokers and fully capture the effect of zero commissions on volume share, even when some

[27] The average daily trading volume per stock is 803,157 shares, and for the entire market is 5,578,598,644 per day in 2019.

[28] The ZCEvent Dummy may be smaller for regressions where the dependent variable is the percentage of market share by volume executed by wholesale market makers using the Boehmer et al. (2021) method, because this sample only contains retail marketable orders that receive price improvement (and excludes marketable orders that execute at the midpoint, NBBO, and outside the NBBO and all non-marketable limit orders).

[29] For instance, Merrill Edge and Wells Fargo offered zero commissions in December 2019. Robinhood has offered was zero commissions since its inception.

Electronic copy available at: https://ssrn.com/abstract=3741470

brokers continue to offer non-zero commissions. Although the increase in retail trading maybe affected by the pandemic, the ZCBroker proportion analysis demonstrates that the results are not dependent on pandemic alone because this variable is changing well before and well after the start of pandemic.

Table 8 shows regression results for off-exchange market share of volume using the proportion of brokers offering zero commissions as the main explanatory variable of interest. The estimated coefficients on ZCBroker Proportion are all positive and statistically significant. These results are consistent with those in Table 7, again suggesting that zero commissions significantly increase the market share of off-exchange wholesale market makers.

****

Add Table 8 about here

****

4.3 Association Between the Zero Brokerage Commission and Market Quality

We examine changes in various dimensions of market quality such as price improvement per share, effective spread, realized spread, price impact and (microstructure) noise. Zero-commissions lower the direct costs of trading, but do they increase the indirect costs by adversely affecting market quality?

One concern regarding the zero- commissions is that retail investors may receive less price improvement per-share when executing marketable orders if retail brokers prefer to earn more payment for order flow. Vlad Tenev, the CEO of Robinhood, confirms that the payment for order

Electronic copy available at: https://ssrn.com/abstract=3741470

flow is an essential revenue source that enables commission-free trading (US House, Committee on House Financial Services, 2021). In fact, the tradeoff between payment for order flow and price improvement for customers has been widely recognized among brokerage firms. In Gensler's (2021) recent testimony before the House Committee on Financial Services he states that in the SEC's recent enforcement action against Robinhood the Commission found that[30]:

"… certain principal trading firms seeking to attract Robinhood's order flow told [Robinhood] that there was a tradeoff between payment for order flow and price improvement for customers. Robinhood explicitly offered to accept less price improvement for its customers in exchange for receiving higher payment for order flow for itself. As a result, many Robinhood customers shouldered the costs of inferior executions; these costs might have exceeded any savings they might have thought they had gotten from a zero commission…"

As commissions decrease, retail brokers may increasingly seek to earn revenue from payment for order flow. Because wholesale market makers probably view both payment for order flow and price improvement as expenses, they may be indifferent to any split between these expenses their gross profit per trade. Consequently, retail brokers choose whether they earn more payment for order flow or provide more price improvement per-share to their retail clients.[31] For example, a broker that eliminated commissions in October 2019, which offered $7.97 in average net price improvement per order reduced this amount to $6.02 in July 2020, for S&P 500 stocks with 1-9,999 share orders.[32] Therefore, we hypothesize that the amount of price improvement

[30] Gensler's testimony before the House Committee on Financial Services is available at https://www.sec.gov/news/testimony/gensler-testimony-20210505#_ftn2.
[31] See item 14 of Securities Act Release No. 10906, "In the Matter of Robinhood Financial, LLC" (Dec. 17, 2020), available at https://www.sec.gov/litigation/admin/2020/33-10906.pdf.
[32] The E*Trade execution quality report for July 2019 and July 2020 are available at https://web.archive.org/web/20190902070137/https://us.etrade.com/trade/execution-quality and https://web.archive.org/web/20200809032323/https://us.etrade.com/trade/execution-quality

Electronic copy available at: https://ssrn.com/abstract=3741470

retail investors received per-share may decrease when commissions are reduced or eliminated. We analyze the magnitude of price improvement per hundred shares using the DTAQ, as this dataset includes odd lots.[33] The results are presented in Table 8.

Using the method that Boehmer et al. (2021) proposed, we identified the subset of retail marketable orders that received price improvement and calculated the volume-weighted amount of price improvement per hundred shares by stock for the pre- and post-zero commission period[34]. Panel A reports the price improvement per hundred shares for all stocks in DTAQ that have a closing price greater than $2. In addition, we examine the top 100 stocks that are held by Robinhood users as identified by Robintrack. The results for these top 100 retail popular stocks are in Panel B. For each panel, we first compare the price improvement per hundred shares for the four months before (06/2019-09/2019) and after (11/2019-02/2020) zero commissions are implemented to minimize the confounding events, such as the COVID shock, and then compare the four months before (06/2019-09/2019) and the corresponding four months in 2020 (06/2020-09/2020) after zero commissions are implemented to control for month and quarter effects.

The results in Table 9 Panel A suggest that the price improvement for all stocks is not immediately affected by the change in commissions, as the change is statistically insignificant. However, when comparing the price improvement from June 2019-September 2019 versus June 2019 – September 2020, the price improvement decreased significantly by -$0.0122 from $0.1716 to $0.1594 per hundred shares which is a -7.11% decline. For the period from June 2019 – September 2019 versus November 2020 – February 2020, Panel B shows that for popular retail stocks, that the reduction in the price improvement (-8.62%) is statistically significant after the

[33] Our measurement unit is "cents per hundred shares".
[34] As discussed in Boehmer et al. (2020), off-exchange midpoint trades are generally institutional orders; hence, we exclude them from the price improvement calculation.

Electronic copy available at: https://ssrn.com/abstract=3741470

implementation of zero commissions by major retail brokers. What's more, if we compare the price improvement amount for retail stocks from June 2019 – September 2019 versus June 2019 – September 2020, price improvement decreases by 11.87%. In sum, the overall results in Table 9 suggest that retail brokerages may offer less price improvement per-share to retail marketable orders to compensate for the loss in revenue from eliminating commissions.

****

Add Table 9 about here

****

Using multivariate regression analysis, we examine the effect of zero commissions on the price improvement controlling for other important factors. To better capture retail trading activity, we use the top 100 stocks that are held and heavily traded by Robinhood retail investors as identified by Robintrack; price improvement for these stocks is expected to be affected more sharply by zero commissions. Specifically, we estimate the impact of zero commissions on price improvement in the following regression:

$$PI_{i,t} = \beta_0 + \beta_1 ZCEvent\ Dummy_t + \beta_2 + \beta_2 Log(Volume_{i,t}) + \beta_3 Log(MktCap_{i,t}) + \beta_3 InvPrice_{i,t} + \beta_4 IntraVol_{i,t} + \beta_5 QS_{i,t} + \varepsilon_{i,t} \quad (3)$$

Where $PI_{i,t}$ is either the volume weighted price improvement (cents) per hundred shares or the volume weighted percent price improvement per share, aggregated at the daily frequency. Our main interest variable is the *ZCEvent Dummy* variable, which takes the value of zero if the date is before the adoption of zero commissions and one if the date after the adoption of zero

Electronic copy available at: https://ssrn.com/abstract=3741470

commissions by major brokers. The regressions also use firm-level variables.[35] All regressions include industry fixed effects and standard errors are double clustered at firm and date levels.

Table 10 reports the findings from estimating equation (3). Table 10 further supports the findings in Table 9: the coefficient estimates on *ZCEvent Dummy* are all negative and statistically significant for price improvement measured in either value or percent terms. The overall results in this section support our hypothesis that after the adoption of zero commissions, retail clients of these brokers receive less price improvement per-share for marketable orders executed by wholesale market makers using univariate tests.

****

Add Table 10 about here

****

Finally, we analyze the effect of zero commissions on liquidity by using DTAQ data. Quoted spreads are the "advertised" cost of a trade and the effective spread is the "actual" cost of trading. The half-effective spread is the cost for removing liquidity with a marketable order. The realized spread captures the profits that liquidity providers earn by posting standing limit orders (net of losses to informed traders), and price impact is the portion of the transaction cost associated with the price discovery through informed marketable orders. Intuitively, price impact is the informed trader's profit and is a proxy for adverse selection costs. We use the top 100 stocks that are held by Robinhood retail investors as identified by Robintrack to test the effect of zero

[35] See Petersen and Fialkowski (1994); Stoll (2000); Bacidore et al. (2002); Chung et al. (2004); Lee and Chung (2009).

Electronic copy available at: https://ssrn.com/abstract=3741470

commissions on market quality for trades executed both on- and off-exchange using DTAQ data in the following regression:

$$ML_{i,t} = \beta_0 + \beta_1 ZCEvent\ Dummy + \beta_2 ShortInterest_{i,t} + \beta_3 logVol_{i,t} + \beta_4 IntraVolatility_{i,t} + \beta_5 \log(MktCap)_{i,t} + \beta_6 InvP_{i,t} + \epsilon \quad (4)$$

The dependent variable *ML* represents different measures of liquidity: average time-weighted percent quoted spread; average percent effective spread; average percent price impact computed based on 5-minute interval and 15-second intervals (O'Hara 2015); average percent realized spread computed based on 5-minute and 15-second intervals (O'Hara 2015). We use the Lee and Ready (1991) algorithm to determine the trade direction for spreads calculation (See Appendix B for details on the methodology). *ZCEvent Dummy* is the main explanatory variable of interest, which takes the value of one if the date is between 9/2019-2/2020, which is four-month period after the adoption of zero commissions by major brokers and takes the value of zero if the date is between 6/2019-9/2019, which is the four- month period before the adoption of zero commissions. The control variables are motivated by past studies of market liquidity (Stoll 2000; O'Hara and Ye, 2011). *ShortInterest* captures the short sale open interest, which is calculated as the number of shares sold short divided by the total number of shares outstanding. *LogVol* is the log of the daily share volume, *IntraVolatility* is the average percentage difference between the intraday high and low price (Bacidore, Battalio, and Jennings, 2002), log(MktCap) is the market capitalization, and *InvP* is the inverse of the stock daily closing price. We controlled for industry fixed effects, and the standard errors are double clustered at the firm and date level.

In addition, we test the effect of zero commissions on microstructure noise by using the following cross-sectional regression:

Electronic copy available at: https://ssrn.com/abstract=3741470

$$IntraVolatility_{i,t} = \beta_0 + \beta_1 ZCEvent\ Dummy + \beta_2 ShortInterest_{i,t} + \beta_3 logVol_{i,t} +$$

$$\beta_4 \log(MktCap)_{i,t} + \beta_5 InvP_{i,t} + \epsilon \quad (5)$$

Following Bacidore, Battalio, and Jennings (2002), we use the average percentage difference between the intraday high and low price to proxy for stock volatility:

$$IntraVolatility = \frac{P_{high;i,t} - P_{low;i,t}}{(P_{hig\ ;i,t} + P_{low;i,t})/2}$$

Table 11 reports the regression results.[36] The ZCEvent Dummy coefficients in Panel A are negative and statistically significant for the average percent effective spread and average percent price impact based on the 5-minute and 15-second time intervals. Meanwhile, the changes in percent quoted spread are insignificant during the sample period of four months before and immediately after zero commissions. However, with further passage of time that allowed the use of zero-commissions to become more commonplace, the percent quoted spread experienced a statistically significant decrease at the 5% level for the matched-months sample period of the four-months in 2020 (Please see internet appendix Table C Panel A). In Table 11 Panel B, the ZCEvent Dummy coefficients for the realized spread based on the 5-minute and 15-second time intervals are both zero and statistically insignificant, which suggests the trading profit to liquidity providers did not change after commissions drop to zero. The fact that the average percent price impact is negative and statistically significant suggests that marketable orders are less informed after commissions drop to zero. The decline in effective spread and price impact is inconsistent with the cream skimming hypothesis of Easley, Kiefer, and O'Hara (1996). The additional fact that realized spreads do not change but effective spreads decline suggests that wholesale market makers serve

[36] We also test the four-month period (06/2019-09/2019) before zero commissions and the corresponding four-month period in 2020 (06/2020-09/2020) to control for month and quarter effects. The results are qualitatively the same and presented in the online appendix.

Electronic copy available at: https://ssrn.com/abstract=3741470

as cost competitors (Battalio, 1997). In addition, the coefficient for the ZCEvent Dummy is positive and significant for stock intraday volatility. This suggests that the microstructure noise increases after commissions drop to zero as retail traders are disproportionally uninformed. The overall results support hypothesis three that the zero brokerage commission changes market quality by decreasing effective spread and price impact, increasing microstructure noise, and leaving realized spreads unchanged.

****

Add Table 11 about here

****

For robust test, Table 12 replicates the regressions of Table 11 by replacing the zero-commission event dummy variable (*ZCEvent Dummy*) with the proportion of retail brokers that adopted offer zero commissions (*ZCBroker Proportion*). The results in Table 12 are consistent with the results reported so earlier and support our hypothesis that zero commissions changes market quality. We find that with a higher proportion of zero commission brokers, effective spread and price impact decrease and market noise increases while the realized spread is unaffected. Overall, the robustness tests reaffirm our baseline results showing that zero commissions by retail brokers influences trading volume share and the market quality.

****

Add Table 12 about here

****

Electronic copy available at: https://ssrn.com/abstract=3741470

To further understand the impact of the zero commissions on market quality, we also test the effect of zero commissions on pricing efficiency measured by variance of pricing error and variance ratio (results are presented in online appendix Table A). In summary, we find that increased retail trading associated with zero commissions does not appear to significantly impact other measures of price efficiency, such as pricing error and variance ratio during our sample period.

5. Conclusion

Major brokerages started offering zero commission trading to retail clients in the fall of 2019 due to intense competitive pressures in that industry. The event provides a fertile testing ground for microstructure theories related to the trade-offs between client's direct and indirect costs, brokers' order routing practices, and the potential trade-off between price improvement and payment for order flow. We first examine the association between zero commissions and volume share and market quality. We find that zero-price commissions appear to be a key driver for retail investors in choosing their broker, as we document dramatic increases (decreases) in market share of client assets for zero (positive) commission brokers using retail brokers' 10Q reports. This finding along with increased search interest for the keywords "free stock trading" in Google Trends indicates that retail investors likely prefer to pay trading costs in a less direct and observable manner, such as potentially through lower interest paid to cash balances, to paying trading costs more directly through commissions.

Consistent with our hypothesis that trade size declines as commission drop to zero, we find that small trade size buckets increase relative to larger ones. Consequently, we infer that retail investors submit more small sized orders after zero commissions. Brokerages who adopt this new

Electronic copy available at: https://ssrn.com/abstract=3741470

policy no longer earn commissions and their potentially optimal strategy is to sell the retail order flow to wholesaler market makers who pay for order flow. Using DTAQ and SEC Rule 605 and 606 reports, we find that retail orders were increasingly routed to and executed by wholesale market makers with exchanges losing market share. Nevertheless, we found a decrease in the amount of price improvement per share after commissions decreased to zero, especially for stocks that are popular among retail investors.

In addition, we empirically find that market quality improves as effective spreads and price impact decline, because wholesale market makers may adjust their quotes with greater frequency, as more uninformed retail orders occur in smaller order size buckets, and retail investors that use non-marketable limit orders are able to jump inside the spread more frequently as the pricing grid is no longer constrained by commissions.

We find that realized spreads are unchanged, suggesting that any new retail orders, triggered by zero commission opportunities, are relatively uninformed. The decline in effective spread and price impact is inconsistent with the cream skimming hypothesis of Easley, Kiefer, and O'Hara (1996). The additional fact that effective spreads fall and realized spreads do not change suggests that wholesale market makers serve as cost competitors (Battalio, 1997). In addition, we find that intraday volatility increases are associated with the drop in commissions, which also suggests retail investors are uninformed.

Our findings offer important implications for public policy. Our results document that retail brokers' order routing decisions are influenced by changes in their commission revenues. The elimination of the commissions may incentivize retail brokers to sell more orders to wholesale market makers, to earn more revenue from payment for order flow to cover the loss of commission revenue. Retail investors may benefit from more publicly available information on how retail

Electronic copy available at: https://ssrn.com/abstract=3741470

brokers are compensated when making their choice of broker. Such information may be particularly important when the costs that retail investors pay are indirect and unobservable.

Electronic copy available at: https://ssrn.com/abstract=3741470

References

Amihud, Yakov. "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects." Journal of Financial Markets 5, no. 1 (2002): 31-56.

Bacidore, Jeffrey M., Robert H. Battalio, and Robert H. Jennings. "Depth improvement and adjusted price improvement on the New York Stock Exchange." Journal of Financial Markets 5, no. 2 (2002): 169-195.

Bakos, Yannis, Henry C. Lucas Jr, Wonseok Oh, Gary Simon, Siva Viswanathan, and Bruce W. Weber. "The impact of e-commerce on competition in the retail brokerage industry." Information Systems Research 16, no. 4 (2005): 352-371.

Barber, Brad M., and Terrance Odean, "The Behavior of individual investors", Handbook of the Economics of Finance, Vol 2, Elsevier, (2013): 1533-1570.

Barber, Brad M., Terrance Odean, and Ning Zhu. "Do retail trades move markets?" The Review of Financial Studies 22, no. 1 (2008): 151-186.

Barrot, Jean-Noel, Ron Kaniel, and David Sraer. "Are retail traders compensated for providing liquidity?" Journal of Financial Economics 120, no. 1 (2016): 146-168.

Bartlett, Robert P., Justin McCrary, and Maureen O'Hara. "The Market inside the Market: Odd-lot Quotes." (November 2021), Working Paper.

Battalio, Robert. "Third market broker-dealers: Cost competitors or cream skimmers?" Journal of Finance 52, no. 1 (1997): 341-352.

Battalio, Robert, Shane A. Corwin, and Robert Jennings. "Can brokers have it all? On the relation between make-take fees and limit order execution quality." The Journal of Finance 71, no. 5 (2016): 2193-2238.

Battalio, Robert, Robert Jennings, and Jamie Selway. "The relationship among market-making revenue, payment for order flow, and trading costs for market orders." Journal of Financial Services Research 19, no. 1 (2001): 39-56.

Battalio, Robert H., and Tim Loughran. "Does payment for order flow to your broker help or hurt you?" Journal of Business Ethics 80, no. 1 (2008): 37-44.

Bell, David E., Ralph L. Keeney, and John DC Little. "A market share theorem." Journal of Marketing Research 12, no. 2 (1975): 136-141.

Black, Fischer. "Noise." The journal of finance 41, no. 3 (1986): 528-543.

Electronic copy available at: https://ssrn.com/abstract=3741470

Boehmer, Ekkehart, Robert Jennings, and Li Wei. "Public disclosure and private decisions: Equity market execution quality and order routing." The Review of Financial Studies 20, no. 2 (2007): 315-358.

Boehmer, Ekkehart, Charles M. Jones, Xiaoyan Zhang, and Xinran Zhang. "Tracking retail investor activity." Journal of Finance, Forthcoming (2021).

Brennan, Michael J., and Tarun Chordia. "Brokerage commission schedules." The Journal of Finance 48, no. 4 (1993): 1379-1402.

Brennan, Michael J., and Patricia J. Hughes. "Stock prices and the supply of information." The Journal of Finance 46, no. 5 (1991): 1665-1691.

Chung, Kee H., Chairat Chuwonganant, and D. Timothy McCormick. "Order preferencing and market quality on NASDAQ before and after decimalization." Journal of Financial Economics 71, no. 3 (2004): 581-612.

Chung, Kee H., Chairat Chuwonganant, and D. Timothy McCormick. "Order preferencing, adverse-selection costs, and the probability of information-based trading." Review of Quantitative Finance and Accounting 27 (2006): 343-364.

Cimon, David A. "Broker routing decisions in limit order markets." Journal of Financial Markets 54 (2021): 100602.

Comerton-Forde, Carole, Katya Malinova, and Andreas Park. "Regulating dark trading: Order flow segmentation and market quality." Journal of Financial Economics 130, no. 2 (2018): 347-366.

De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann. "Noise trader risk in financial markets." Journal of Political Economy 98, no. 4 (1990): 703-738.

Easley, David, Nicholas M Kiefer, and Maureen O'Hara. "Cream-skimming or profit-sharing? The curious role of purchased order flow." Journal of Finance 51, no. 3 (1996): 811-833.

Eaton, Gregory W. and Green, T. Clifton and Roseman, Brian and Wu, Yanbin. "Zero-Commission Individual Investors, High Frequency Traders, and Stock Market Quality (January 1, 2021) ". Available at SSRN: https://ssrn.com/abstract=3776874

Ernst, Thomas and Chester Spatt. "Payment for Order Flow and Asset Choice." (December 2021). Working Paper.

Foucault, Thierry, David Sraer, and David J. Thesmar. "Individual investors and volatility." The Journal of Finance 66, no. 4 (2011): 1369-1406.

Electronic copy available at: https://ssrn.com/abstract=3741470

Fox, Merritt B., Lawrence Glosten, and Gabriel Rauterberg. *The new stock market*. Columbia University Press, 2019.

Gensler, Gary (Chairman of the U.S. Securities and Exchange Commission). "Testimony Before the House Committee on Financial Services" (Date: 5/6/2021) Text from: https://www.sec.gov/news/testimony/gensler-testimony-20210505#_ftn2

Goldstein, Michael A., Paul Irvine, Eugene Kandel, and Zvi Wiener. "Brokerage commissions and institutional trading patterns." The Review of Financial Studies 22, no. 12 (2009): 5175-5212.

Heimer, Rawley, and Alp Simsek. "Should retail investors' leverage be limited?" Journal of Financial Economics 132, no. 3 (2019): 1-21.

Hendershott, Terrence, and Pamela C. Moulton. "Automation, speed, and stock market quality: The NYSE's hybrid." Journal of Financial Markets 14, no. 4 (2011): 568-604.

Ho, Thomas and Hans Stoll. "Optimal dealer pricing under transactions and return uncertainty." Journal of Financial Economics 9, no. 1, (1981): 47-73.

Holden, Craig W., and Stacey Jacobsen. "Liquidity measurement problems in fast, competitive markets: Expensive and cheap solutions." The Journal of Finance 69, no. 4 (2014): 1747-1785.

Jennings, Richard W. "The New York Stock Exchange and the Commission Rate Struggle." Cal L. Rev. 53 (1965): 1119.

Kaniel, Ron, Gideon Saar, and Sheridan Titman. "Individual investor trading and stock returns." The Journal of finance 63, no. 1 (2008): 273-310.

Kelley, Eric K., and Paul C. Tetlock. "How wise are crowds? Insights from retail orders and stock returns." The Journal of Finance 68, no. 3 (2013): 1229-1265.

Kumar, Alok., and Charles M.C. Lee. "Retail investor sentiment and return comovements." Journal of Finance 61 (2006), 2451-2486.

Kurov, Alexander. "Information and noise in financial markets: Evidence from the E-Mini index futures." Journal of Financial Research 31, no. 3 (2008): 247-270.

Larrymore, Norris L., and Albert J. Murphy. "Internalization and market quality: An empirical investigation." Journal of Financial Research 32, no. 3 (2009): 337-363.

Lee, Charles MC, and Mark J. Ready. "Inferring trade direction from intraday data." The Journal of Finance 46, no. 2 (1991): 733-746.

Electronic copy available at: https://ssrn.com/abstract=3741470

Lee, Kaun Y., and Kee H. Chung. "Information-Based Trading and Price Improvement." Journal of Business Finance & Accounting 36, no. 5-6 (2009): 754-773.

Mackintosh, Phil. “A New Way to Look at Retail Trading Trends.” Nasdaq, November 18, 2021. https://www.nasdaq.com/articles/a-new-way-to-look-at-retail-trading-trends.

Malinova, Katya, and Andreas Park. "Subsidizing liquidity: The impact of make/take fees on market quality." The Journal of Finance 70, no. 2 (2015): 509-536.

O'Donoghue Shawn. "Transaction Fees: Impact on Order Types, Commissions, and Execution Quality of Institutional Investors." (2021), Unpublished manuscript.

O’Hara, Maureen. "High frequency market microstructure." Journal of Financial Economics 116, no. 2 (2015): 257-270.

O'Hara, Maureen, and Mao Ye. "Is market fragmentation harming market quality?" Journal of Financial Economics 100, no. 3 (2011): 459-474.

Parlour, Christine and Uday Rajan. “Payment for Order Flow.” Journal of Financial Economics Volume 68, no. 3, (2003): 379-411.

Payne, J., J. R. Bettman, and E. J. Johnson. "Consumer decision making." Handbook of Consumer Behavior (1991): 50-84.

Petersen, Mitchell A. "Estimating standard errors in finance panel data sets: Comparing approaches." The Review of Financial studies 22, no. 1 (2009): 435-480.

Petersen, Mitchell A., and David Fialkowski. "Posted versus effective spreads: Good prices or bad quotes?" Journal of Financial Economics 35, no. 3 (1994): 269-292.

Royal, James. "In the race to zero-fee broker commissions, here's who the big winner is", https://www.bankrate.com/investing/zero-fee-broker-commissions-long-term-investors-win/ (2019).

Shampanier, Kristina, Nina Mazar, and Dan Ariely. "Zero as a special price: The true value of free products." Marketing Science 26, no. 6 (2007): 742-757.

Shleifer, Andrei, and Lawrence H. Summers. "The noise trader approach to finance." Journal of Economic Perspectives 4, no. 2 (1990): 19-33.

Simonson, Itamar, and Amos Tversky. "Choice in context: Tradeoff contrast and extremeness aversion." Journal of Marketing Research 29, no. 3 (1992): 281-295.

Stambaugh, Robert F. “Presidential Address: Investment Noise and Trends”. The Journal of Finance 69, no. 4 (2014): 1415–53. doi:10.1111/jofi.12174.

Electronic copy available at: https://ssrn.com/abstract=3741470

Stoll, Hans R. "Presidential address: friction." The Journal of Finance 55, no. 4 (2000): 1479-1514.

Thompson, Samuel B. "Simple formulas for standard errors that cluster by both firm and time." Journal of financial Economics 99, no. 1 (2011): 1-10.

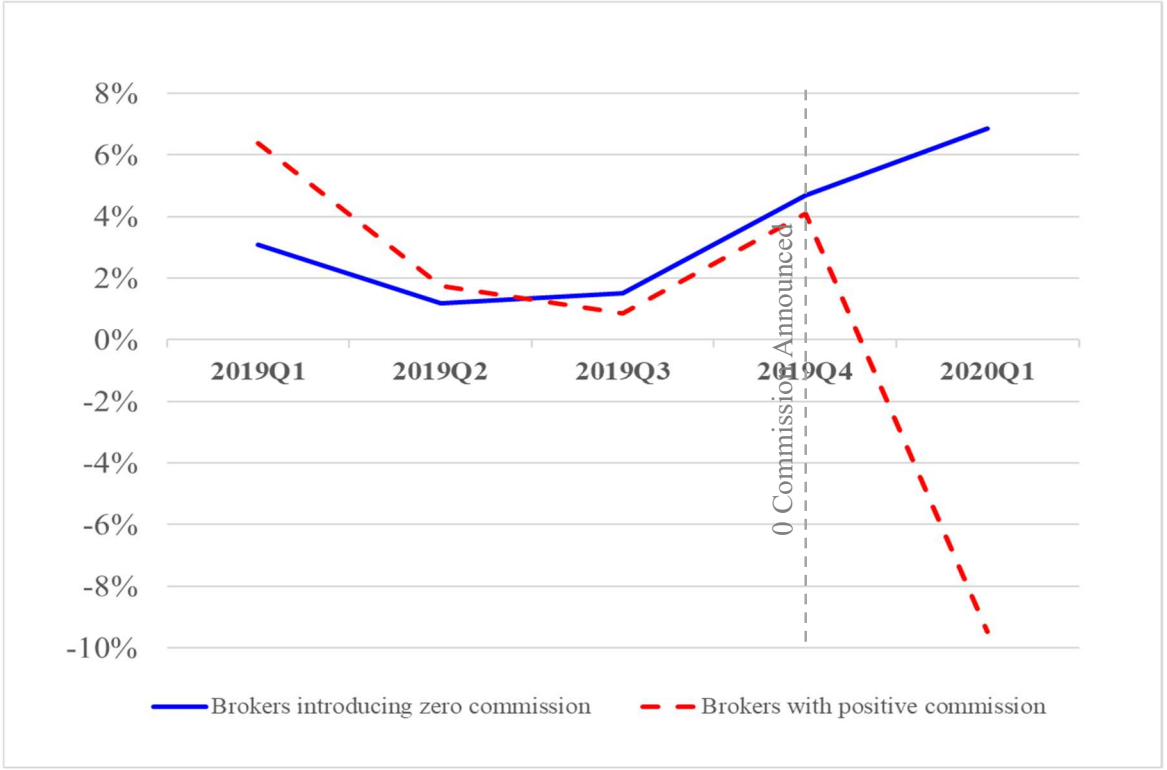
US House, Committee on House Financial Services. "Game Stopped? Who Wins and Loses When Short Sellers, Social Media, and Retail Investors Collide?" February 18, 2021. https://www.congress.gov/event/117th-congress/house-event/111207.

Electronic copy available at: https://ssrn.com/abstract=3741470

Figure 1. Net Change in Broker's Client Assets

Figure 1(a) provides the quarterly net change in broker's client assets from Q1 2019 to Q1 2020 for both retail brokers with and without zero commissions. The blue solid line represents the brokers that introduce the zero-commissions in October 2019, and the red dashed line represents the brokers that still charge positive commissions during our sample. The grey vertical line denotes the time of the event when several retail brokers announce zero-commission trading. Figure 1(b) shows the average change in client assets after dropping to zero commissions with the magnitude of the drop. The retail brokers that announced zero-commissions for this figure are: Ally Invest, Charles Schwab, E*Trade, Raymond James, and TD Ameritrade. Retail brokers with non-zero commissions are Edward Jones, LPL, Morgan Stanley, Muriel Siebert, and Stifel. The data is collected from retail brokers' 10-Q reports.[42]

(a) Net Change in Broker's Client Assets after Adopting Zero Commission

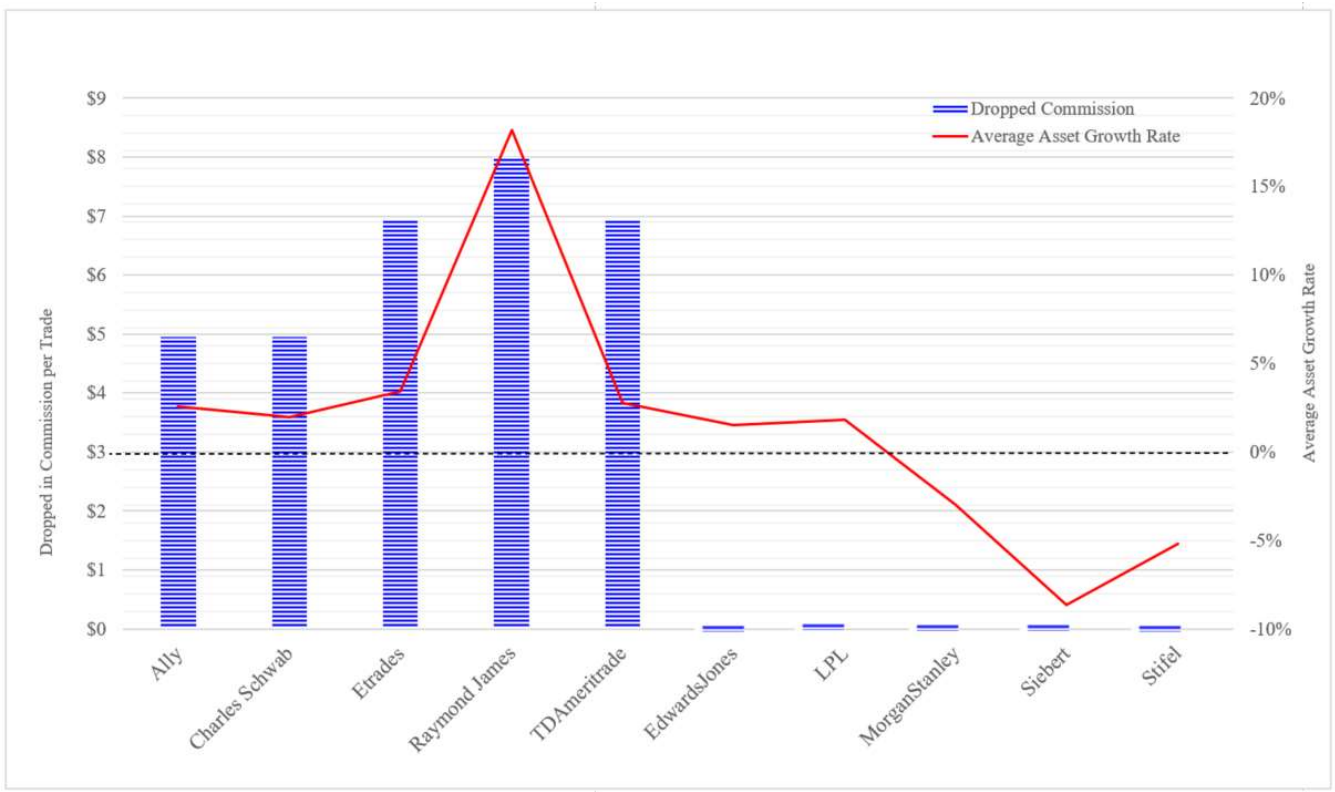


[42] Four retail brokers in our later analysis in this paper are not included in this figure: Fidelity and Zacks Trade are private holding firms. Therefore, their public quarterly financial statements are not available. BB&T Securities LLC merged with SunTrust in fourth quarter of 2019, and Citi Group's 10Q report does not provide the information about net new investors' asset for brokerage services.

Electronic copy available at: https://ssrn.com/abstract=3741470

(Figure 1 Continued)

(b) Change in Client Asset with Magnitude of Drop in Commission by Broker



Electronic copy available at: https://ssrn.com/abstract=3741470

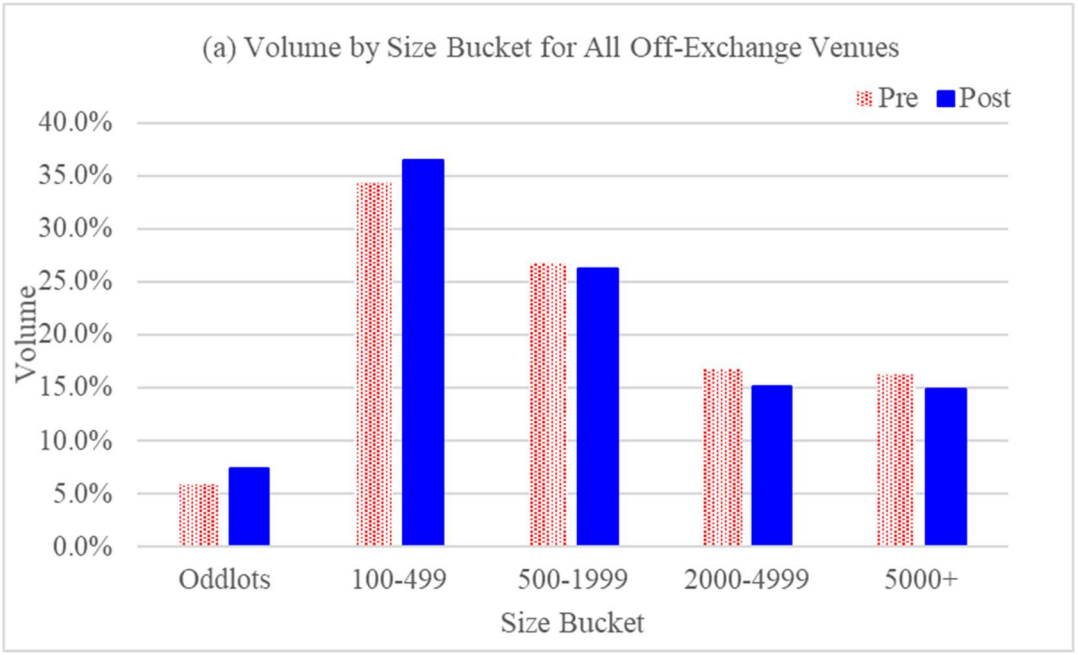
Figure 2. Search Interest of "Free Stock Trading" from Google Trends Index

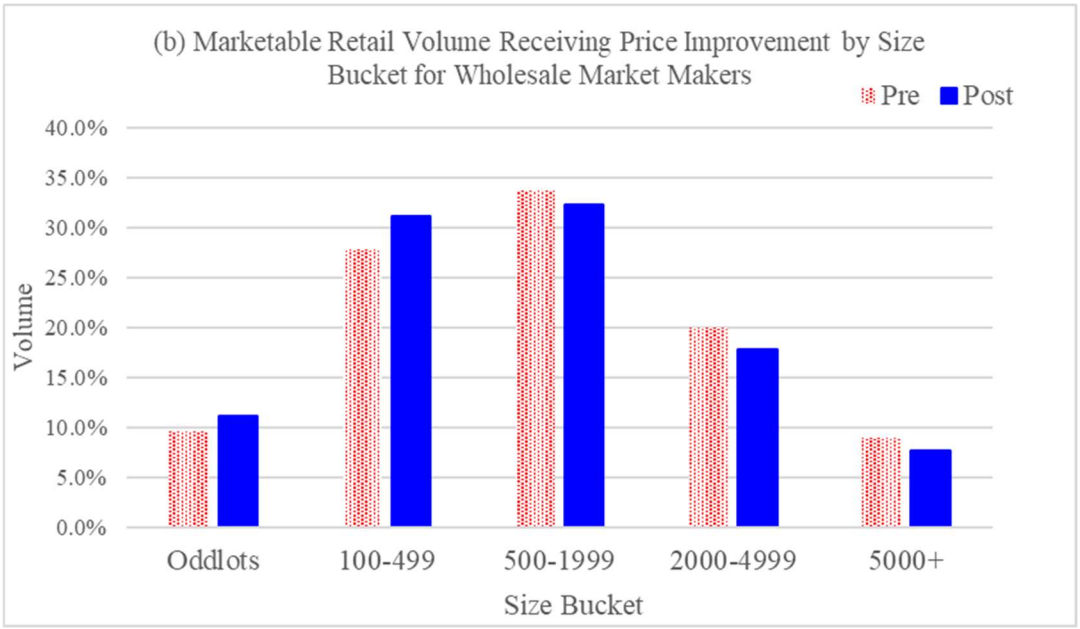
This figure shows the search interest of "free stock trading" from 06/2019-06/2020 from Google Trends (https://trends.google.com/trends/?geo=US). Each data point in normalized Google Trends Index is divided by the total searches of the geography and time range it represents to compare relative popularity, and the numbers are on weekly basis and scaled on a range of 0 to 100 based on a topic's proportion to all searches on all topics as defined by Google Trends Index. The grey region shows the time periods that strongly influence the retail trading participation.

Electronic copy available at: https://ssrn.com/abstract=3741470

Figure 3. Change in Volume by Trade Size Bucket

Panel (a) provides the change in the percentage of volume for each trade size bucket for all off-exchange venues before versus after commissions drop to zero. Panel (b) provides the change in the percent of volume for each trade size bucket before versus after zero commissions drop to zero for the subset of marketable retail orders that received price improvement from wholesale market makers as identified by Boehmer et al. (2021). Our sample includes all stocks that trade above $2.00 during regular trading hours (9:30 am - 4:00 pm) from 06/2019 to 02/2020. Pre (red color with dotted fill) and Post (blue color with solid fill) denote four months before (06/2019-09/2019) and after (11/2019-02/2020) the major retail brokers eliminate commissions. All measures are estimated from DTAQ.

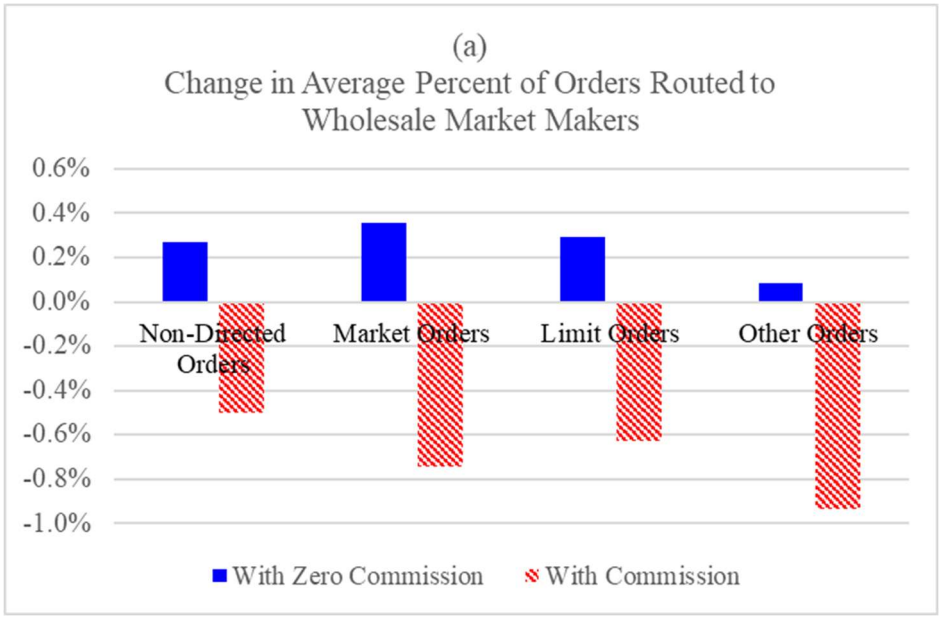


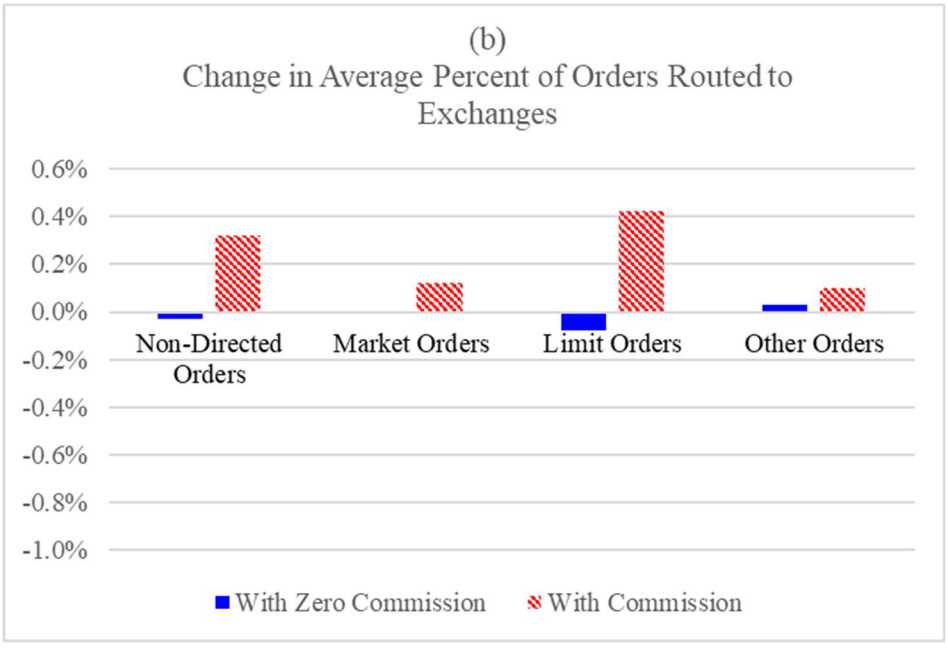


Electronic copy available at: https://ssrn.com/abstract=3741470

Figure 4. Average Change in the Percent of Orders Routed to Wholesale Market Makers and Exchanges by Retail Brokers

This figure provides the average change in the percent of orders routed for execution by retail brokers to different execution venue types weighted by the number of retail brokers for each order type between Q3 and Q4 2019, for retail brokers with and without zero commissions. Panel (a) refers to the change in average percent routed to wholesale market makers and Panel (b) refers to the average change in the percent of orders routed to exchanges between Q3 and Q4 2019 for those retail brokers that eliminated commissions in October 2019 (Blue color with solid fill) and others that still charge commissions (Red color with diagonal strips fill) as of April 1, 2020. The retail brokers that announced zero commissions in October 2019 used in our study are Ally Invest, Charles Schwab, E*Trade, Fidelity, Raymond James, and TD Ameritrade. The retail brokers with non-zero commissions as of April 1, 2020 are BB&T Securities LLC, Citi Group, Edward Jones, LPL Financial, Morgan Stanley, Muriel Siebert, Stifel, and Zacks Trade. The wholesale market makers (Citadel, G1X, Two Sigma, UBS, and Virtu) and the exchanges (Arca, EDGX, Nasdaq, and NYSE) are identified from retail brokers SEC Rule 606 reports.



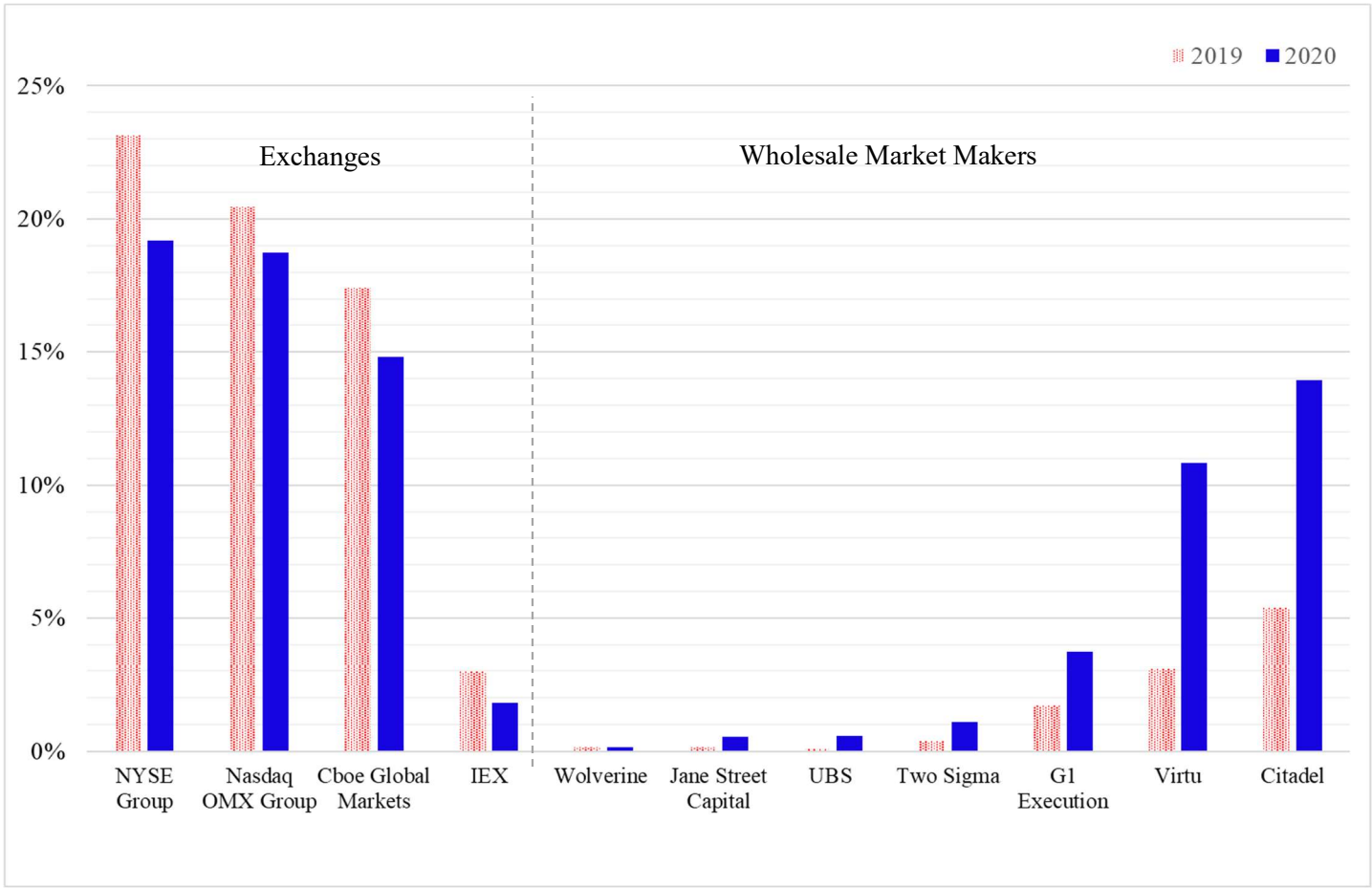


Electronic copy available at: https://ssrn.com/abstract=3741470

Figure 5. U.S. Stock Market Share of Volume by Venue Before vs. After Zero Commissions

This figure shows the market share of volume by venue before (August 2019) versus after (August 2020) zero commissions were implemented. The market share of volume is calculated as the number of shares executed on a particular venue divided by the total number of shares executed on all venues. Panel A reports the market share of volume by venue in 2019 (Red color with dotted fill) vs. 2020 (Blue color with solid fill), and Panel B reports the changes in market share of volume by venue before vs. after zero brokerage commission. Volume for NYSE Group (NYSE (N), NYSE Arca (P), NYSE American (A), NYSE National (C) and NYSE Chicago (M)), Nasdaq OMX Group (NASDAQ (Q), NASDAQ BX (B) NASDAQ PSX (X)) and Cboe Global Markets (EDGA Equities (J), EDGX Equities (K), BYX Equities (Y) and BZX Equities (Z)) are from Cboe Global Markets. Volume for wholesale market makers is from FINRA's publicly available (Non-ATS) OTC Transparency Data (https://otctransparency.finra.org).

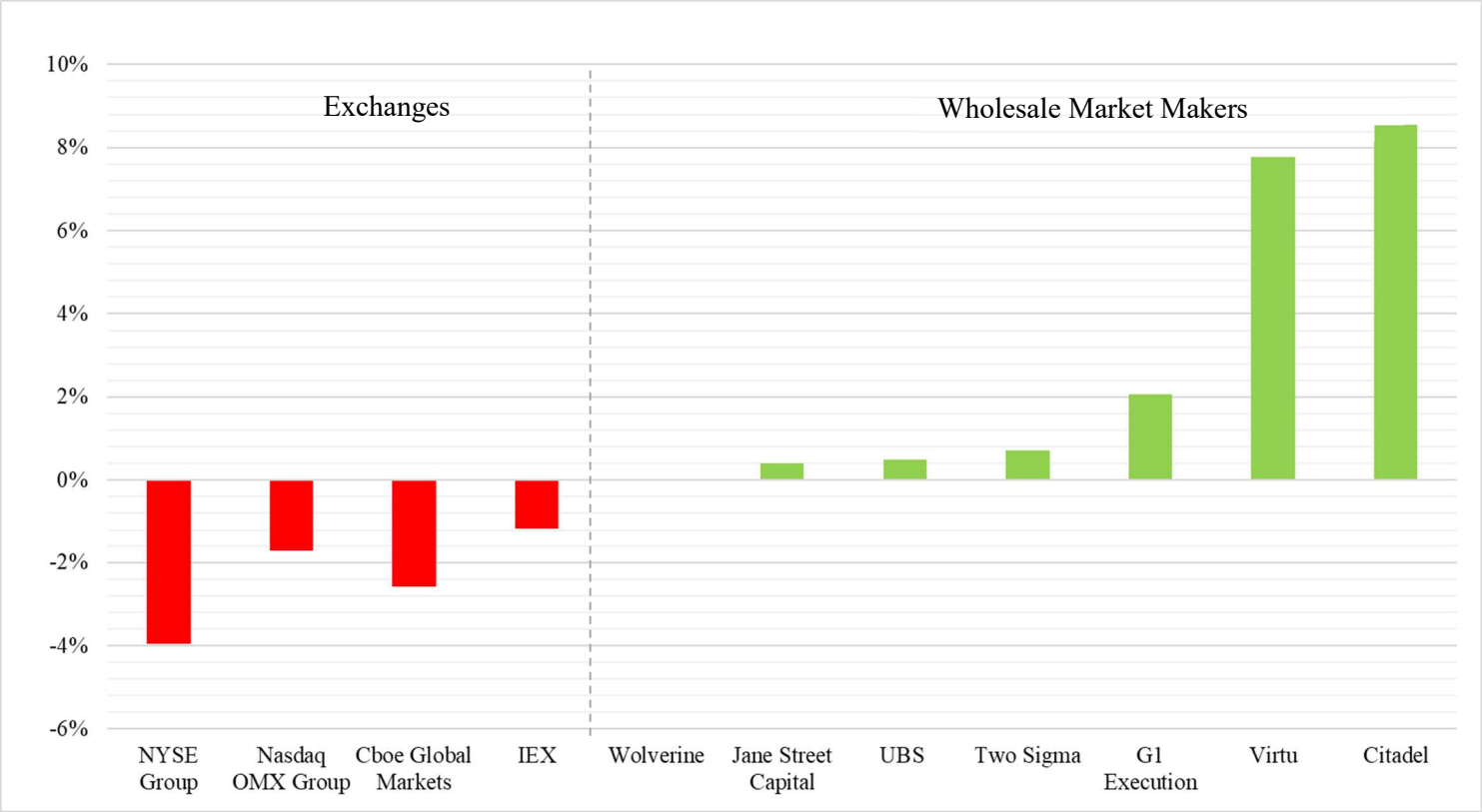
Panel A. Market Share of Volume by Venue Before vs. After Zero Commissions



Electronic copy available at: https://ssrn.com/abstract=3741470

(Figure 5 Continued)

Panel B. Changes in Market Share of Volume by Venue Before vs. After Zero Brokerage Commission



Electronic copy available at: https://ssrn.com/abstract=3741470

Table 1. List of Wholesale Market Makers and Retail Brokers

This table lists the wholesale market makers and retail brokers that are examined in this study. Panel A lists the wholesale market makers and their payments for receiving orders; Panel B lists the retail brokers that charge and do not charge commissions. The payments paid by wholesale market makers are identified from SEC Rule 606, and the commissions charged by retail brokers are from each broker's official website as of April 1, 2020.

Panel A: Wholesale market makers

Brokerage Firm	**Payment/Share**
Citadel	$ 0.0010-0.0021
Virtu	$ 0.0014-0.0024
G1X	$ 0.0015- 0.0020
Two-Sigma	$ 0.0015-0.0020
UBS	$ 0.0017-0.0026

Panel B: Retail Brokers

Brokerage Firm	**Commission**	**Zero-Commission Effective Day**
Interactive Brokers	0	10/9/2019
TD Ameritrade	0	10/3/2019
Charles Schwab	0	10/7/2019
Fidelity	0	10/10/2019
Ally Invest	0	10/9/2019
E*Trade	0	10/7/2019
Raymond James	0	10/21/2019
Zacks Trade	$ 0.01 per share	-
Morgan Stanley	2.25% for <=$199,999 cumulative principal	-
Edwards Jones	2.5% for <$5,999.99	-
Stifel	Minimum (10% Principal, $40)	-
LPL	1.5% of transaction	-
BB&T	2.5% for <$2,000	-
Muriel Siebert	$ 14.95/ trade	-
Citi Group	0.18%-0.24% per trade	-

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 2: Size Analysis

This table presents the difference-in-difference (DID) results for the average change in total number of shares executed for by order size bucket and order type across wholesale market makers (Citadel, G1X, Two Sigma, UBS, Virtu). The sample includes all stocks that trade above $2.00, and the pre- and post- denote four months before and after the major retail brokers implement zero brokerage commissions. The difference (i.e., *Diff*) is calculated as Post minus Pre. Order size is categorized into three groups: 100-1999, 2000-4999, and 5000 or more shares, respectively. The data is obtained from SEC Rule 605 Reports. DID denotes the difference between the size bucket of 100-1999 and 2000-5000 or more. Standard t-tests are used to calculate the difference. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

		Small		**Large**			**DID**	
	Order Size	**100-1999**		**2000-4999**	**5000+**		**Small - Large**	
Marketable Order	*Pre*	943,761.3		567,736.7	465,358.3			
	Post	1,207,569.7		603,521.1	502,308.2			
	Diff (+/-)	263,808.4		35,784.4	36,949.9		262,642.9	
	Diff (%)	27.95%	***	6.30% ***	7.94%	***	20.9%	***
	T-stat	*(12.04)*		*(2.44)*	*(2.56)*		*(7.44)*	
		100-1999		**2000-4999**	**5000+**		**Small - Large**	
At- or Inside-Quote Limit Order	*Pre*	59,104.8		36,275.4	33,542.6			
	Post	83,433.7		45,447.6	45,211.7			
	Diff (+/-)	24,328.9		9,172.2	11,669.1		21,832.0	
	Diff (%)	41.16%	***	25.28% ***	34.79%	***	11.3%	*
	T-stat	*(9.94)*		*(6.28)*	*(4.17)*		*(1.89)*	
		100-1999		**2000-4999**	**5000+**		**Small - Large**	
Outside-Quote Limit Order	*Pre*	50,630.2		41,883.0	47,471.4			
	Post	67,314.2		48,556.2	54,712.2			
	Diff (+/-)	16,684.1		6,673.2	7,240.8		16,116.5	
	Diff (%)	32.95%	***	15.93% ***	15.25%	***	17.38%	***
	T-stat	*(8.63)*		*(4.17)*	*(3.67)*		*(2.36)*	

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 3. Fixed-effects Regressions for Trading Size

This table reports the results from estimating the following fixed-effects regression equation for our sample of stocks having a price above $2.00 from wholesale market makers' Rule 605 reports from 06/2019-02/2020:

$$VolumeShare_{i,t} = \alpha + \beta_1 ZCEvent\ Dummy + \beta_2 RetailPop_i + \beta_3 ZeroCommission \times RetailPop_i + \beta_4 Volatility_{i,t} + \beta_5 VIX_t + \beta_6 \log(MktCap)_{i,t} + \beta_7 InvPrice_{i,t} + \beta_7 Effective\ Spread_{i,t} + \epsilon_{i,t} \quad (1)$$

$$VolumeShare_{i,t} = \alpha + \beta_1 ZCEvent\ Dummy + \beta_2 RetailPop_i + \beta_3 ZeroCommission \times RetailPop_i + \beta_4 Volatility_{i,t-1} + \beta_5 VIX_{t-1} + \beta_6 \log(MktCap)_{i,t-1} + \beta_7 InvPrice_{i,t-1} + \beta_8 Effective\ Spread_{i,t-1} + \epsilon_{i,t} \quad (2)$$

The dependent variables are the proportion of shares executed for stock *i* in month *t*, in the smaller order size buckets of less than 1,999 shares divided by the total shares executed in all order size buckets. The main independent variable is *ZCEvent Dummy*, which is a dummy variable that equals 1 for the months after than October 2019. $RetailPop_t$ is a dummy variable equal to 1 if the stock *i* is the top 100 stocks held by Robinhood users in month *t* as identified by Robintrack. $Volatility_i$ is measured by the standard deviation of a stock's daily return per month across. VIX_t is the monthly realization of the US volatility index (VIX*)*. $Log(MktCap)_i$ is the natural log of market capitalization. $InvPrice_i$ is the inverse of the mean monthly closing price from CRSP. $Effective\ Spread_i$ is the share-weighted effective spread for stock *i* that are executed in each month. Month fixed effects are included. T-Stats are reported in parentheses. Standard errors are double clustered at the stock and month level. ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.10 level, respectively.

	(1) **Contemporaneous Controls Proportion of Executed Shares for Order Size Bucket of 100-1,999 Shares**		(2) **Lagged Controls Proportion of Executed Shares for Order Size Bucket of 100-1,999 Shares**	
ZCEvent Dummy	0.013	***	0.011	***
	(4.33)		*(4.02)*	
$RetailPop_i$	-0.102	***	-0.106	***
	(-15.48)		*(-15.71)*	
ZCEvent Dummy ×$RetailPop_i$	0.049	***	0.05	***
	(5.42)		*(5.49)*	
$Volatility_t$	-0.604	***		
	(-5.81)			
VIX_t	0.00			
	(1.54)			
$Log(MktCap)_t$	-0.007	***		
	(-13.03)			
$InvPrice_t$	-0.547	***		
	(-13.63)			
Effective $Spread_t$	0.346	***		
	(17.11)			
$Volatility_{t-1}$			-0.512	***
			(-5.00)	
VIX_{t-1}			0.00	
			(0.01)	
$Log(MktCap)_{t-1}$			-0.007	***
			(-12.21)	
$InvPrice_{t-1}$			-0.513	***
			(-12.49)	
Effective $Spread_{t-1}$			0.345	*
			(10.38)	
Constant	0.745	***	0.742	***
	(125.74)		*(68.41)*	
Time Fixed Effects	Yes		Yes	
R^2	0.24		0.23	
Observations	52,506		52,257	

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 4. Volume by Trade Size Bucket from DTAQ dataset

This table presents univariate results for the average change in volume by trade size bucket executed off-exchange. The sample includes all stocks that trade above $2.00 and pre- and post- denote four months before (06/2019-09/2019) and after (11/2019-02/2020 major retail brokers drop commissions to zero. Panel A reports the change in total volume executed by all off-exchange venues; Panel B reports the change in volume for marketable retail trades that receive price improvement as identified by Boehmer et al. (2021). Panel C shows the change in volume by size bucket for marketable retail trades executed by wholesale market makers that received price improvement versus all off-exchange trades. The data is obtained from DTAQ. Numbers are reported in thousands. Paired t-tests in parenthesis are used to calculate the differences between pre- and post-periods. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

Panel A: Total Volume Executed by All Off-Exchange Venues

Order Size	**Small**			**Large**		**DID**	
	Odd lots	**100-499**	**500-1999**	**2000-4999**	**5000+**	**Small - Large**	
Pre	1,709.92	9,989.94	7,768.73	4,857.99	4,740.38		
Post	2,771.80	13,732.25	9,904.22	5,695.47	5,601.16		
Diff (+/-)	1,061.88	3,742.32	2,135.50	837.48	860.77	5,241.44	
Diff (%)	62.10%	37.46%	27.49%	17.24%	18.16%	17.95%	***
T-stat	*(2.26)*	*(3.06)*	*(3.27)*	*(4.10)*	*(4.17)*	*(2.47)*	

Panel B: Volume of Marketable Retail Trades that Receive Price Improvement Executed from Wholesale Market Makers

Order Size	**Small**			**Large**		**DID**	
	Odd lots	**100-499**	**500-1999**	**2000-4999**	**5000+**	**Small - Large**	
Pre	396.1	1,155.2	1,396.7	826.9	369.5		
Post	635.9	1,789.3	1,852.8	1,023.9	436.6		
Diff (+/-)	239.8	634.1	456.1	197.0	67.0	1,065.89	
Diff (%)	60.53%	54.89%	32.65%	23.83%	18.14%	23.04%	***
T-stat	*(7.26)*	*(9.97)*	*(7.86)*	*(4.08)*	*(2.52)*	*(2.22)*	

Panel C: Percent of Total Volume from All Off-Exchange Venues vs. Marketable Retail Trades that Received Price Improvement from Wholesale Market Makers

	Percent of Total Volume Executed Off-Exchange				**Percent of Marketable Retail Trades that Received Price Improvement**		
	Pre	Post	Difference		Pre	Post	Difference
Odd lots	5.88%	7.35%	1.47%	**Odd lots**	9.56%	11.08%	1.52%
100-499	34.37%	36.42%	2.05%	**100-499**	27.87%	31.18%	3.31%
500-1999	26.73%	26.27%	-0.46%	**500-1999**	33.70%	32.29%	-1.41%
2000-4999	16.71%	15.11%	-1.61%	**2000-4999**	19.95%	17.84%	-2.11%
5000+	16.31%	14.86%	-1.45%	**5000+**	8.92%	7.61%	-1.31%
Total	100%	100%		**Total**	100%	100%	

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 5. Average Change in the Percent of Orders Routed to Wholesale Market Makers and Exchanges by Retail Brokers

This table presents difference-in-difference results for the average change in the percent of orders routed for execution by retail brokers to different execution venue types weighted by the number of retail brokers for each order type between Q3 and Q4 2019, for both retail brokers with and without zero commissions. The retail brokers that announced zero commissions in October 2019 used in this analysis are Ally Invest, Charles Schwab, E*Trade, Fidelity, Raymond James, and TD Ameritrade. The retail brokers with non-zero commissions as of April 1, 2020 are BB&T Securities LLC, Citi Group, Edward Jones, LPL Financial, Morgan Stanley, Muriel Siebert, Stifel, and Zacks Trade. The average percent routed for execution is calculated from each broker's SEC Rule 606 Q3 and Q4 2019 reports for the three listing exchanges (Nasdaq, NYSE, and NYSE American) and wholesale market makers (Citadel, G1X, Two Sigma, UBS, and Virtu) before versus after the zero-commission event. Standard t-tests are used to calculate the differences between the two groups. Statistical significance at the 10%, 5% and 1% levels is denoted by *, **, and ***, respectively.

	Broker with zero commission						Broker with positive commission							
Execution Broker/Venue	N	Mean	Stdev	Min	Max	Execution Broker/Venue	N	Mean	Stdev	Min	Max	DID	t-value	
To Wholesale Market Maker						*To Wholesale Market Maker*								
Non-Directed Orders	65	0.27%	2.30%	-3.76%	2.83%	Non-Directed Orders	53	-0.50%	2.27%	-4.21%	4.89%	0.77%	1.82	*
Market Orders	65	0.36%	2.89%	-3.85%	3.83%	Market Orders	53	-0.74%	1.83%	-5.01%	0.99%	1.10%	2.41	**
Limit Orders	65	0.29%	2.22%	-3.40%	3.83%	Limit Orders	53	-0.63%	1.50%	-3.24%	1.04%	0.92%	2.56	**
Other Orders	65	0.09%	3.40%	-7.23%	4.58%	Other Orders	53	-0.93%	2.72%	-5.60%	4.71%	1.02%	1.77	*
To Exchange						*To Exchange*								
Non-Directed Orders	198	-0.03%	0.31%	-3.45%	1.17%	Non-Directed Orders	297	0.32%	3.16%	-14.60%	24.70%	-0.34%	-1.84	*
Market Orders	198	0.00%	0.00%	0.00%	0.00%	Market Orders	297	0.12%	0.99%	-3.01%	6.62%	-0.12%	-2.12	*
Limit Orders	198	-0.08%	0.77%	-9.45%	1.52%	Limit Orders	297	0.42%	3.30%	-15.60%	30.70%	-0.50%	-2.52	***
Other Orders	198	0.03%	0.16%	-0.47%	1.40%	Other Orders	297	0.10%	3.13%	-21.50%	25.61%	-0.08%	-0.42	

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 6: Regressions for the Change in the Percent of Orders Routed to Wholesale Market Makers and Exchanges by Retail Brokers

This table presents regressions testing the change in the percent of orders by type routed to either wholesale market makers or exchanges. The zero commission broker dummy (ZCBroker Dummy) equals one for those brokers who announced zero brokerage commission in October 2019 and equals zero for those brokers with non-zero commissions. The retail brokers that announced zero brokerage commissions in October 2019 used in this analysis are Ally Invest, Charles Schwab, E*Trade, Fidelity, Raymond James, and TD Ameritrade. The retail brokers with non-zero commissions as of April 1, 2020 are BB&T Securities LLC, Citi Group, Edward Jones, LPL Financial, Morgan Stanley, Muriel Siebert, Stifel, and Zacks Trade. The dependent variable *ΔNon-directed, ΔMarket, ΔLimit* and *ΔOther* are the retail brokers' change in the percent of non-directed, market, limit, and other orders from Q3 to Q4 2019 for wholesale market makers and exchanges. The change in the percent of order by type is from each broker's SEC Rule 606 Q3 and Q4 2019 reports. All regressions include broker and listing exchange fixed effect. T-Stats are reported in parentheses. ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.10 level, respectively.

Panel A: Change in percent of orders routed to wholesale market makers by order type				
	ΔNon-Directed	ΔMarket	ΔLimit	ΔOther
ZCBroker Dummy	0.0596 **	0.0595 **	0.0389	0.0638 *
	(2.33)	*(2.16)*	*(1.33)*	*(1.91)*
Intercept	-0.02	-0.005	-0.0133	-0.0255
	(-1.34)	*(-0.29)*	*(-0.77)*	*(-0.30)*
Broker F. E	Yes	Yes	Yes	Yes
Listing F. E	Yes	Yes	Yes	Yes
R^2	0.11	0.11	0.23	0.19
Observations	130	130	130	130
Panel B: Change in percent of orders routed to exchanges by order type				
	ΔNon-Directed	ΔMarket	ΔLimit	ΔOther
ZCBroker Dummy	-0.0119 **	-0.0001	-0.0161 ***	0.0018
	(-2.09)	*(-0.07)*	*(-2.67)*	*(0.32)*
Intercept	0.0126	0.0003	0.1687 ***	-0.0011
	(0.48)	*(0.20)*	*(3.74)*	*(-0.26)*
Broker F. E	Yes	Yes	Yes	Yes
Listing F. E	Yes	Yes	Yes	Yes
R^2	0.14	0.11	0.19	0.16
Observations	462	462	462	462

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 7: Change in Market Share of Volume

This table reports coefficient estimates for OLS regressions of off-exchange daily volume market share from DTAQ using controls and the implementation of zero-brokerage commissions by leading retail brokers as an event. The sample includes all stocks that trade above $2.00 during regular trading hours (9:30 am - 4:00 pm) from 06/2019-02/2020. For the dependent variables, we consider the percentage of total off-exchange volume share for all order and trader types in columns (1) and (2), and for marketable retail orders that receive price improvement off-exchange from wholesale market makers as identified by Boehmer et al. (2021) in column (3) and (4). All variables are described in detail in Appendix A. t-statistics are reported in parentheses and are based on standard errors clustered at the date and stock level. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	Total Off-exchange Volume Share	**Total Off-exchange Volume Share**	**Price Improved Off-exchange Retail Volume Share**	**Price Improved Off-exchange Retail Volume Share**
	All Orders and Trader Types	**All Orders and Trader Types**	**Boehmer et al. (2021)**	**Boehmer et al. (2021)**
	(1)	(2)	(3)	(4)
ZCEvent Dummy	1.685 ***	1.589 ***	0.435 ***	0.485 **
	(43.51)	*(42.07)*	*(18.43)*	*(20.94)*
Log (Volume)		0.647 ***		-0.341 ***
		(35.61)		*(-28.17)*
Log (MktCap)	-0.194 ***	-0.226 ***	-0.119 ***	0.162 ***
	(-12.53)	*(-10.95)*	*(-10.34)*	*(10.34)*
InvPrice	15.425 ***	13.011 ***	12.45 ***	13.279 ***
	(27.62)	*(28.7)*	*(31.15)*	*(32.27)*
VIX	-0.009 *	-0.023 ***	0.004	0.015 ***
	(-1.72)	*(-4.74)*	*(1.33)*	*(4.90)*
Lag(Spread*100)	0.117 ***	0.19 ***	0.167 ***	0.098 ***
	(5.11)	*(5.03)*	*(4.89)*	*(5.38)*
Amihud ($x10^5$)	-0.006		-0.004	
	(-1.52)		*(-1.53)*	
Constant	33.133 ***	0.647 ***	6.209 ***	6.209 ***
	(41.60)	*(35.61)*	*(15.77)*	*(15.77)*
Index F.E.	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
R^2	0.20	0.21	0.25	0.25
Observations	929,149	929,149	929,149	929,149

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 8: The Effect of the Proportion of Zero Commission Retail Brokers on Change in Market Share of Volume

This table reports coefficient estimates for OLS regressions of the share of off-exchange daily market volume from DTAQ using controls and the implementation of zero-brokerage commissions as an event. The sample includes all stocks that trade above $2.00 during regular trading hours (9:30 am - 4:00 pm) from 06/2019-02/2020. For the dependent variables, we consider the percentage of total off-exchange volume share for all order and trader types in columns (1) and (2), and for retail marketable orders that receive price improvement off-exchange as identified by Boehmer et al. (2021) in column (3) and (4). The main independent variable is the *ZCBroker Proportion*, which is the proportion of retail brokers that offer zero commission trading. All variables are described in detail in Appendix A. t-statistics are reported in parentheses and are based on standard errors clustered at the date and stock level. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	Total Off-exchange Volume Share All Orders and Trader Types (1)	**Total Off-exchange Volume Share All Orders and Trader Types** (2)	**Price Improved Off-exchange Retail Volume Share Boehmer et al. (2021)** (3)	**Price Improved Off-exchange Retail Volume Share Boehmer et al. (2021)** (4)
ZCBroker Proportion	4.053 ***	3.897 ***	1.039 ***	1.152 ***
	(46.57)	*(45.58)*	*(19.41)*	*(21.96)*
Log (Volume)		0.647 ***		-0.342 ***
		(37.22)		*(-30.03)*
Log (MktCap)	0.231 ***	-0.216 ***	-0.104 ***	0.180 ***
	(14.98)	*(-11.13)*	*(-9.35)*	*(12.29)*
InvPrice	15.399 ***	13.035 ***	12.403 ***	13.263 ***
	(29.7)	*(30.38)*	*(33.24)*	*(34.4)*
VIX	-0.018 ***	-0.036 ***	0.003	0.013 ***
	(-3.8)	*(-7.58)*	*(0.91)*	*(4.62)*
Lag(Spread*100)	0.127 ***	0.211 ***	0.18 ***	0.104 ***
	(5.32)	*(5.08)*	*(5.01)*	*(5.48)*
Amihud ($x10^5$)	-0.007		-0.004	
	(-1.54)		*(-1.53)*	
Constant	24.756 ***	27.306 ***	8.164 ***	5.815 ***
	(32.35)	*(35.68)*	*(20.83)*	*(15.11)*
Index F.E.	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
R^2	0.20	0.20	0.25	0.25
Observations	1,052,012	1,102,428	1,052,012	1,102,428

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 9. Price Improvement Analysis

This table presents univariate results for the change in the average amount of price improvement per 100 shares for marketable retail orders executed by wholesale market makers as identified by Boehmer et al. (2021) before versus after commissions decline to zero. Panel A reports the price improvement for all stocks that trade above $2.00, and Panel B reports the price improvement for the top 100 stocks that are held by Robinhood users as identified by Robintrack. *Pre* and *Post* denote four months before (06/2019 – 09/2019) and after (11/2019 – 02/2020) the major retail brokers implement zero-commissions, or four months before (06/2019-09/2019) zero commissions were widely adopted and the corresponding four months in 2020 (06/2020-09/2020) to control for month and quarter effects. The data is obtained from DTAQ trade. Paired t-tests are used to calculate the differences between pre- and post-periods. Statistical significance at the 10%, 5%, and 1% level is denoted by *, **, and ***, respectively

Panel A: All stocks						
	Pre (¢)	Post (¢)	Diff. +/-	Diff (%)	T-Stat	
06/2019 - 09/2019 vs. 11/2019 - 02/2020	17.16	17.33	0.16	0.95%	1.42	
06/2019 - 09/2019 vs. 06/2020 - 09/2020	17.16	15.94	-1.22	-7.11%	-12.83	***
Panel B: Top 100 popular retail stocks as identified by Robintrack						
	Pre (¢)	Post (¢)	Diff. +/-	Diff (%)	T-Stat	
06/2019 - 09/2019 vs. 11/2019 - 02/2020	16.26	14.86	1.40	-8.62%	-7.71	***
06/2019 - 09/2019 vs. 06/2020 - 09/2020	16.26	14.33	1.93	-11.87%	-8.61	***

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 10. Regressions for Price Improvement on Zero Commission Event

This table presents coefficient estimates when regressing price improvement on the ZCEvent Dummy for the top 100 stocks that are held by Robinhood users as identified by Robintrack and which have a price greater than $2.00. The dependent variables are the volume weighted price improvement (in cents) per hundred shares and volume weighted percent price improvement per share; both measures are aggregated at daily level. Following Boehmer et al. (2021), the trades have midpoint price improvement are eliminated in the calculation. The main independent variable is *ZCEvent Dummy*, which is a dummy variable that equals 1 if the time is greater than October 2019. All variables are described in Appendix A. Column (1) is the sample for four months before and after the major retail brokers implement zero commission. Column (2) is the four months before (06/2019-09/2019) zero commissions were widely adopted and the corresponding four months in 2020 (06/2020-09/2020) to control for month and quarter effects All regressions include the industry fixed effects, and the standard errors are double clustered at the firm and date level. T-Stats are reported in parentheses. Standard errors are double clustered at the stock and date level. ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.10 level, respectively.

	Price Improvement per 100 Shares (¢)		**Price Improvement per Share** (%)	
	(1)	(2)	(1)	(2)
	6/2019-9/2019 vs. 11/2019-2/2020	6/2019-9/2019 vs. 6/2020-9/2020	6/2019-9/2019 vs. 11/2019-2/2020	6/2019-9/2019 vs. 6/2020-9/2020
ZCEvent Dummy	-1.009 ***	-1.293 ***	-0.007 ***	-0.012 ***
	(-8.70)	*(-11.41)*	*(-7.32)*	*(-12.26)*
LogVol	-0.962 ***	-0.879 ***	0.001	-0.002 ***
	(-12.55)	*(-12.66)*	*(0.85)*	*(-3.78)*
Log(MktCap)	0.511 ***	0.405 ***	-0.015 ***	-0.017 ***
	(10.97)	*(9.76)*	*(-23.96)*	*(-27.99)*
InvP	0.044	0.969 ***	0.120 ***	0.092 ***
	(0.14)	*(3.10)*	*(10.42)*	*(10.72)*
IntraVolatility	0.039	-0.026	0.003 ***	0.001 ***
	(1.48)	*(-1.20)*	*(5.04)*	*(3.68)*
Quoted Spread ($)	-0.833	0.161	0.090 ***	0.053 ***
	(-1.51)	*(0.82)*	(15.21)	(27.36)
Constant	21.838 ***	21.607 ***	0.135 ***	0.391 ***
	(17.93)	*(19.84)*	*(39.55)*	*(31.55)*
Industry F.E.	Yes	Yes	Yes	Yes
R^2	0.051	0.049	0.761	0.707
Observations	12,864	13,284	12,864	13,284

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 11. Fixed-effects Regressions for Market Quality Measures

This table reports the results from regressing market quality measures on a ZCEvent Dummy for the top 100 stocks that are held by Robinhood users as identified by Robintrack and which have a price greater than $2.00. The dependent variable in Panel A are the liquidity measures: Average time-weighted percent quoted spread, average percent effective spread, and average percent price impact computed based on 5-minute interval and 15-second intervals. The dependent variables in Panel B are average percent realized spread computed based on 5-minute and 15-second intervals, stock intraday volatility, IntraVolatility, which is the average percentage difference between the intraday high and low price. The main independent variable is *ZCEvent Dummy*, which is a dummy variable equals 1 if the time is greater than October 2019. ShortInterest captures the short sale open interest, which is calculated as the number of shares sold short divided by the total number of shares outstanding. logVol is the log of the daily share volume, log(MktCap) is the market capitalization, and InvP is the inverse of daily closing price for that stock. All dependent variables are computed from DTAQ database. Stock short interest information is from the Compustat Supplemental Short Interest File, and market capitalization and closing price is from CRSP. All regressions include the industry fixed effects, and the standard errors are double clustered at the firm and date level. The sample period is from 06/2019-02/2020. T-Stats are reported in parentheses. Standard errors are double clustered at the stock and date level. ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.10 level, respectively.

Panel A: Market Liquidity

	Quoted Spread *(%)*	Effective Spread *(%)*	Price Impact: 5-min *(%)*	Price Impact: 15-sec *(%)*
ZCEvent Dummy	0.000	-0.002***	-0.003 ***	-0.002 ***
	(-0.44)	*(-6.34)*	*(-4.29)*	*(-4.53)*
ShortInterest	0.002***	0.005***	0.008***	0.017***
	(0.53)	*(2.73)*	*(2.87)*	*(8.84)*
LogVol	-0.016***	-0.008***	-0.005***	-0.007***
	(-21.12)	*(-19.81)*	*(-7.62)*	*(-16.92)*
IntraVolatility	-0.012***	0.272***	0.552***	0.408***
	(-17.21)	*(9.57)*	*(8.13)*	*(11.79)*
Log(MktCap)	0.23***	-0.005***	-0.006***	-0.009***
	(8.39)	*(-10.58)*	*(-7.78)*	*(-23.70)*
InvP	0.616***	0.515***	0.222***	0.064***
	(38.50)	*(46.01)*	*(16.01)*	*(9.71)*
Constant	0.632***	0.292***	0.235***	0.347***
	(40.09)	*(30.95)*	*(16.21)*	*(44.77)*
Industry F.E.	Yes	Yes	Yes	Yes
R^2	0.78	0.79	0.59	0.67
Observations	14,381	14,381	14,381	14,381

Electronic copy available at: https://ssrn.com/abstract=3741470

(Table 11 Continued)

Panel B: Profit to Liquidity Providers and Market Noise			
	Realized Spread: 5-min *(%)*	Realized Spread: 15-sec *(%)*	IntraVolatility (%)
ZCEvent Dummy	0.00	0.00	0.204 ***
	(0.75)	*(-0.24)*	*(4.41)*
ShortInterest	-0.002	-0.005 ***	1.228 ***
	(-0.92)	*(-2.87)*	*(5.70)*
LogVol	-0.003 ***	-0.006 ***	0.991 ***
	(-5.82)	*(-16.26)*	*(27.30)*
IntraVolatility	-0.28 ***	-0.062 ***	
	(-5.87)	*(-3.23)*	
Log(MktCap)	0.001	0.002 ***	-0.659 ***
	(1.17)	*(5.66)*	*(-23.14)*
InvP	0.294 ***	0.407 ***	0.175
	(21.02)	*(41.60)*	*(0.31)*
Constant	0.057 ***	0.050 ***	2.226 ***
	(4.29)	*(5.77)*	*(3.30)*
Industry F.E.	Yes	Yes	Yes
R^2	0.49	0.79	0.233
Observations	14,381	14,381	14,381

Electronic copy available at: https://ssrn.com/abstract=3741470

Table 12. The Effect of the Proportion of Zero Commission Retail Brokers on Market Quality

This table reports the results from regressing market quality measures on the proportion of the number of retail brokers that offer zero commission trading, ZCBroker Proportion. for the top 100 stocks that are held by Robinhood users as identified by Robintrack and which have a price greater than $2.00. The dependent variable in Panel A are the liquidity measures: Average time-weighted percent quoted spread, average percent effective spread, and average percent price impact computed based on 5-minute interval and 15-second intervals. The dependent variables in Panel B are average percent realized spread computed based on 5-minute and 15-second intervals, stock intraday volatility, IntraVolatility, which is the average percentage difference between the intraday high and low price. The main independent variable is the *ZCBroker Proportion*, which is the proportion of the number of retail brokers that offer zero commission trading. ShortInterest captures the short sale open interest, which is calculated as the number of shares sold short divided by the total number of shares outstanding. logVol is the log of the daily share volume, log(MktCap) is the market capitalization, and InvP is the inverse of daily closing price for that stock. All dependent variables are computed from DTAQ database. Stock short interest information is from the Compustat Supplemental Short Interest File, and market capitalization and closing price is from CRSP. All regressions include the industry fixed effects, and the standard errors are double clustered at the firm and date level. The sample period is from 06/2019-02/2020. T-Stats are reported in parentheses. Standard errors are double clustered at the stock and date level. ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.10 level, respectively.

Panel A: Market Liquidity

	Quoted Spread *(%)*	Effective Spread *(%)*	Price Impact: 5-min *(%)*	Price Impact: 15-sec *(%)*
ZCBroker Proportion	0.006	-0.005**	-0.008 ***	-0.007 ***
	(1.34)	*(-1.96)*	*(-3.98)*	*(-5.73)*
ShortInterest	-0.034***	-0.018***	0.009***	0.019***
	(-4.64)	*(-4.78)*	*(2.63)*	*(8.28)*
LogVol	-0.007***	0.000	0.000	-0.005***
	(-4.88)	*(-0.70)*	*(-0.62)*	*(-12.77)*
IntraVolatility	0.240***	0.270***	0.741***	0.511***
	(5.81)	*(6.95)*	*(11.05)*	*(16.30)*
Log(MktCap)	-0.031***	-0.018***	-0.012***	-0.011***
	(-43.25)	*(-38.2)*	*(-23.94)*	*(-40.34)*
InvP	0.176***	0.197***	0.063***	0.017***
	(17.54)	*(25.08)*	*(10.94)*	*(5.69)*
Constant	1.036***	0.539***	0.334***	0.376***
	(39.79)	*(56.09)*	*(35.35)*	*(66.84)*
Industry F.E.	Yes	Yes	Yes	Yes
R^2	0.66	0.89	0.54	0.67
Observations	16,310	16,310	16,310	16,310

Electronic copy available at: https://ssrn.com/abstract=3741470

(Table 12 Continued)

Panel B: Profit to Liquidity Providers and Market Noise			
	Realized Spread: 5-min *(%)*	Realized Spread: 15-sec *(%)*	IntraVolatility (%)
ZCBroker Proportion	0.004	0.003	0.005 ***
	(1.43)	*(1.58)*	*(3.72)*
ShortInterest	-0.027 ***	-0.028 ***	0.011 ***
	(-6.98)	*(-8.59)*	*(5.11)*
LogVol	0.000 ***	-0.001 *	0.012 ***
	(0.03)	*(-1.89)*	*(28.84)*
IntraVolatility	-0.471 ***	-0.164 ***	
	(-9.46)	*(-5.16)*	
Log(MktCap)	-0.006 ***	-0.006 ***	-0.007 ***
	(-11.44)	*(-15.37)*	*(-33.15)*
InvP	0.134 ***	0.188 ***	0.007 ***
	(15.77)	*(25.03)*	*(3.70)*
Constant	0.205 ***	0.229 ***	0.012 ***
	(18.75)	*(25.24)*	*(2.22)*
Industry F.E.	Yes	Yes	Yes
R^2	0.63	0.77	0.27
Observations	16,310	16,310	16,310

Electronic copy available at: https://ssrn.com/abstract=3741470

Anonymous Internet Appendix

https://docs.google.com/document/d/e/2PACX-1vSxcadtY3k7eYMxtMJS7X2uSwfffPGfRSgCEwsoiyITFc02i-OeBgfTiYXPZ44wBEkwcMBOCFVPzZlS/pub

Appendix A: Variable Definitions

Variable	Definition
ZCEvent Dummy	Dummy variable equals one if the time is after October 2019, and zero before. We exclude the month of October 2019 from the analysis.
ZCBroker Proportion	The proportion of the number of retail brokers that offer zero-commission trades.
ZCBroker Dummy	Dummy equals one for brokers that announced zero commissions in October 2019 and equals zero for those brokers with non-zero commissions
RetailPop	Dummy variable equals one if the stock belongs to the top 100 stocks held by most Robinhood users in given the period, *t*
Amihud (x10^5)	Amihud illiquidity ratio multiplied by a factor of 10^5
Log(Daily Volume)	Natural log of the average daily trading dollar-volume
Log(Trade)	Natural log of the number of daily trades
Log(MktCap)	Natural log of market capitalization
InvPrice	The inverse of the closing price
IntraVolatility	The average percentage difference between the intraday high and low price
VIX	Daily Volatility index
lag(Spread*100)	Lag of the quoted spread multiplied by a factor of 100
SI	The number of shares sold short divided by total number of shares outstanding

Electronic copy available at: https://ssrn.com/abstract=3741470

Appendix B: Identification of Buy/Sell Orders and Liquidity Measures

The following measures of market liquidity are proposed by Holden and Jacobsen (2014). We use these liquidity measures to analyze market quality. For measuring spreads, we use the DTAQ intraday data to link quote and trade and identify all the trades that fit our criteria into buy and sell by using the following algorithm.

First, we match each stock trade with the prevailing NBBO quote at the end of the previous millisecond. Next, we compute the midpoint for each NBBO quote, and then classify the trading direction ("Buy" or "Sell") for each trade using the following three conventions

Trade Direction	**Direction Sign**	**Lee and Ready (1991)**
Buy	+1	When trade price is higher than the assigned quote midpoint
Sell	-1	When trade price is lower than the assigned quote midpoint
Tick Test		When the trade price does not fit the above buy/sell direction criteria
		Buy (+1): When the price for last trade is lower than the current trade
		Sell (-1): When the price for last trade is higher than the current trade

Finally, after identifying the trading direction, we use the following liquidity measures to examine the market quality

Quoted Spread

Percent — The difference between the national best offer (NBO) minus the national best bid (NBB) divided by the midpoint M_t of the NBB and NBO for a given time interval

Effective Spread

Percent — The difference between each trade price and midpoint M_t of assigned NBB and NBO multiplied by twice the trading direction divided by the midpoint M_t of associated NBB and NBO

Realized Spread

Percent_5min — The difference between each trade price and the midpoint M_{t+5}, five minutes after the midpoint of the associated NBB and NBO divided by the midpoint M_t of the associated NBB and NBO

Percent_15sec — The difference between each trade price and the midpoint M_{s+15}, fifteen seconds after the midpoint of the associated NBB and NBO divided by the midpoint M_s of the associated NBB and NBO

Price Impact

Percent_5min — The five-minute difference between the midpoint M_t and M_{t+5} of the NBB and NBO multiplied by twice the trading direction and divided by the midpoint M_t

Percent_15sec — The fifteen seconds difference between the midpoint M_s and M_{s+15} of the NBB and NBO multiplied by twice the trading direction and divided by the midpoint M_s

Electronic copy available at: https://ssrn.com/abstract=3741470