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March 28, 2023

Ms. Vanessa A. Countryman, Secretary
U.S. Securities and Exchange Commission
100 F Street, NE
Washington, D.C. 20549-1090

Re: File No. S7-31-22; Release No. 34-96495; Order Competition Rule ("Auctions Proposal")

Dear Ms. Countryman,

My colleague, Professor Robert Jennings, and I are providing this submission for the Securities and Exchange Commission's comment file regarding the Proposal on Regulation NMS: Order Competition Rule.[1] This submission contains a copy of our latest paper, "On the Potential Cost of Mandating Qualified Auctions for Marketable Retail Orders." In our paper, we employ what we believe to be superior data and methodologies than those used by the Commission in their 'fade analysis' to estimate the potential costs imposed by failures in the proposed auctions (e.g., auctions that fail to produce an execution) on retail execution quality. We find that the Commission's use of 'inferred' retail trades and execution-time quote benchmarks results in potential cost estimates that are lower than those obtained when using actual retail orders and order receipt time quote benchmarks. In reasonable scenarios, we find that the annualized potential costs of failed auctions greatly exceed $2 billion, which is greater than the Commission's estimate of the annualized 'competitive shortfall' of $1.5 billion that the proposed auctions are designed to deliver to retail investors.

Based on our analysis, we encourage the Commission to table the proposed Order Competition Rule. We support the passage of the proposed Disclosure of Order Execution Information rule and encourage the Commission to patiently wait and see how enhanced disclosures help competitive forces reduce and/or eliminate any 'competitive shortfall' that might exist in the market for marketable retail orders.

We appreciate the opportunity to contribute to this important discussion.

Sincerely,

Robert Battalio
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[1] See https://www.sec.gov/rules/proposed/2022/34-96495.pdf.

This Draft: March 28, 2023

On the Potential Cost of Mandating Qualified Auctions for Marketable Retail Orders

by

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Acknowledgements: We thank one or more wholesalers for providing the data used in this analysis. We have not been paid to conduct this analysis. Our motivation for writing this paper is to provide information that may inform policy. Any errors in this document are the responsibility of the authors.

Executive Summary:

The Securities and Exchange Commission utilizes an algorithm developed by Boehmer et al. (2021) that is known to have both type I errors (i.e., falsely identify institutional trades as retail) and type II errors (i.e., identify only a subset of actual retail trades) to classify trades that the NYSE's publicly available TAQ database shows were reported to a Trade Reporting Facility (i.e., a TRF) to estimate the potential costs of failed auctions in its proposed Order Competition Rule. To better understand the ramifications of utilizing an inferior dataset, rather than CAT data, to examine the potential costs of failed auctions, we conduct a fade analysis using all marketable retail orders routed to one or more wholesalers in May 2022 and adjust several of the inputs used to estimate the potential costs of failed auctions. Some of our findings are as follows. (1) The percentage of executed shares in marketable orders for which the midquote moves against the retail investor rises from 13.46% at 25 milliseconds after order receipt time, to 19.22% at 100 milliseconds, and to 22.37% at 300 milliseconds. This compares to SEC fade probabilities of 1.8% at 25 milliseconds, to 2.8% at 100 milliseconds, and to 4.6% at 300 milliseconds obtained for their sample of trades identified as retail trades by the Boehmer et al. algorithm (e.g., the BJZZ algorithm). (2) Expected fade costs for orders measured using midquote moves against the retail investor are 3 to 7.8 times larger than the SEC's estimate. (3) When price improvement is considered, the potential cost of failed auctions estimated using 300 millisecond mark-out quotes are higher than the $2 billion upper bound estimate of the potential benefits of successful auctions. (4) The Commission estimates there is an annualized 'competitive shortfall' of $1.5 billion for marketable retail orders in the current market structure. More specifically, the proposed Order Competition Rule specifies "that the time period for a qualified auction must be no shorter than 100 milliseconds (1/10th of a second) and no longer than 300 milliseconds (3/10ths of a second) after an auction message is provided for dissemination in consolidated market data." We estimate the annualized cost of adverse movements computed 100 milliseconds after orders are received by wholesaler(s), which is the duration of the shortest proposed auction, ranges from $1.73 billion to $1.88 billion. When we use the length of the longest proposed auction, the annualized cost ranges from $2.17 billion to $2.55 billion.

We conclude that the potential costs of failed auctions may be on the same order of magnitude as the potential benefits of successful auctions. In several of the scenarios we examine, the Commission's auction proposal has the potential of creating a net loss for retail investors even if one accepts the Commission's estimated benefit. We believe the Commission would reach similar conclusions if it used actual retail orders and our revised methodology. Given our results and the high degree of uncertainty as to how the Commission's Order Competition Proposal will impact equity markets, we suggest the Commission table this rule proposal. As we wrote in our 2016 paper, "Can Brokers Have it all? On the Relation between Make-Take Fees and Limit Order Execution Quality" written with Shane Corwin, we believe the rule changes contained in the Commission's proposed Disclosure of Order Execution Information rule will go a long way toward eliminating ***any*** inefficiencies in the market for marketable retail orders.

The U.S. Securities and Exchange Commission (SEC) has proposed amending Regulation NMS with Rule 615 – the Order Competition Rule – to "…promote competition as a means to protect the interests of individual investors…".[2] The proposed rule would prohibit a restricted competition trading center from internally executing certain marketable[3] orders without first exposing them to competition in a qualified auction. The proposed rule appears to be motivated by the Commission's concern regarding the competitiveness of the extant market structure surrounding individual investors' orders. Currently, the vast majority of retail investors' marketable orders are routinely routed to one of six electronic market makers known as wholesalers. Wholesalers provide nearly instantaneous execution of these orders at prices that are typically better than the contemporaneously posted National Best Bid or Offer (NBBO) prices regardless of order size. Because the current market structure segments retail order flow from institutional order flow and routes these retail orders based on historical execution quality among wholesalers operating in an industry the Commission believes is highly concentrated, the SEC believes that auctions for individual orders will produce prices more favorable to retail investors. The SEC's economic analysis suggests that the benefit from this change in market structure would provide between $0.0015 and $0.0047 per share better prices.

Included in the Commission's economic analysis (see Section VII.C.1.b.i. – Greater Variation in Execution Quality) is a consideration of the potential costs imposed on retail investors by auctions that fail to produce an execution.[4] Currently, retail investors behave as if they believe that they will receive the quoted price or better regardless of order type or order size. For example, Battalio and Jennings (2022) find that nearly 70% of the marketable orders submitted to one or more wholesalers in May 2022 are simple

[2] See https://www.sec.gov/rules/proposed/2022/34-96495.pdf.

[3] A marketable order is an order that is executable immediately given the current quoted prices. This includes market orders and marketable limit orders with limit prices outside the current best quoted prices (i.e., limit buy orders with prices equal to or greater than the current National Best Offer and limit sell orders with prices equal to or less than the current National Best Bid).

[4] Our analysis follows what we believe is the thrust of the SEC's analysis in being agnostic regarding the cause of the auction failure. Although auctions could fail for technical reasons or for lack of interest by counter-parties, this paper demonstrates (we believe consistently with the SEC's fade analysis) that movements in the National Best Bid and/or Offer price are a substantial threat to the proposed auctions' success.

market orders that do not limit the amount by which the order's execution might move the price.[5] Although many retail orders are for few shares, the tendency is to submit market orders even for those orders with sizes considerably exceeding the quoted NBBO size. In the section of the SEC's proposed rule change noted above, the SEC states that it "…is cognizant of concerns regarding the possibility of a decline in execution quality due to the implementation of qualified auctions." The Commission believes that orders in failed auctions could "quickly" be redirected to another auction, sent to rest on an exchange's limit order book, or internalized by the wholesaler at prices benchmarked to the ***order receipt time*** NBBO. The Commission concedes that it is possible that there would be quote price slippage in the process. The Commission performed a "fade analysis" to estimate the potential cost associated with these auction failures and concluded that the potential cost was small compared to the estimated benefit.

We perform an alternative analysis using actual order and trade data from one or more wholesalers during May 2022 and conclude that the SEC's analysis severely under-estimates the potential costs of failed auctions.[6] Specifically, we find that the frequency of quote slippage and the amount of quote slippage even over short periods of time is considerably higher than that estimated by the Commission. We find that the expected potential cost per executed share in our sample of marketable retail orders routinely exceeds the lower bound per share benefit estimated by the Commission and can exceed the upper bound.

We believe there are at least four reasons for the differences in the Commission's fade analysis and the fade analysis conducted in this paper: (1) our sample consists of all trades resulting from all marketable retail orders routed to one or more wholesalers in May 2022 while the Commission's sample consists of trades reported to a Trade Reporting Facility that are identified to be retail by the Boehmer et al. algorithm, which omits a significant percentage of retail trades and incorrectly includes institutional trades; (2) our sample includes orders placed in all securities by retail investors while the Commission's sample consists

[5] See "Why do Brokers who do not Charge Payment for Order Flow Route Marketable Orders to Wholesalers," available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4304124.
[6] These are the same data that are analyzed in Battalio and Jennings (2022). Please see that paper for a detailed description of the order data used in this analysis.

of BJZZ-inferred retail trades in a set of 600 randomly selected stocks and exchange traded funds; (3) we use order receipt times to evaluate the potential cost of failed auctions while the Commission uses trade times; and (4) we use the actual order side when computing fade costs while the Commission uses the BJZZ-inferred order side.

Our methodology for estimating the potential cost associated with failed auctions differs in important ways from the methodology used by the Commission. We begin with all marketable ***orders*** from one or more wholesalers during May 2022 in over 10,000 NMS securities and exchange traded funds. Instead of using its CAT dataset of retail orders, the Commission uses the algorithm developed in Boehmer et al. (2021), hereafter BJZZ, to identify potential retail ***trades*** from the consolidated tape and applied that to a random sample of 600 NMS securities and exchange traded funds to create the dataset used in the Commission's fade analysis.[7] Thus, using our dataset, we can measure auction failure cost from ***order receipt time***, the same time mandated by the SEC's Rule 605 to evaluate execution quality, not trade time as the commission uses in the proposal.[8] Despite a relatively short period between order arrival time and execution time, we demonstrate that costs measured using order arrival time benchmarks significantly exceed costs computed using trade time benchmarks. In addition, we use the BJZZ algorithm to examine all of the wholesaler trades and demonstrate a substantive difference between the cost estimate provided by BJZZ-identified wholesaler trades and the cost estimate provided by BJZZ-unidentified wholesaler trades. We find the costs associated with the BJZZ-identified trades (consistent with the SEC approach) is considerably smaller, which suggests the BJZZ algorithm is potentially biased.[9] ***Regardless of the subset of orders/trades examined, we find that the frequency with which the quote moves against the investor is much higher in our sample than that found by the Commission (1.8% versus 9.6% at 25 milliseconds post trade, 2.8% versus 13.2% at 100 milliseconds post trade, and 4.6% versus 18.4% at 300 milliseconds***

[7] The paper can be downloaded at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2822105.
[8] See "Final Rule: Disclosure of Order Execution and Routing Practices," available at: https://www.sec.gov/rules/final/34-43590 htm
[9] Because our analysis begins with a set of known retail orders, we have no false positives (i.e., institutional orders identified as retail by the BJZZ algorithm) in our analysis. Battalio et al. (2022) demonstrate that the BJZZ algorithm likely contains many known institutional orders in their sample of "retail" orders.

post trade).[10] Finally, the SEC simply assumes that the quote changes by a penny for all of the time intervals examined. ***We actually measure the quote change and find that it frequently changes by substantially more than $0.01.***

The Commission estimates that the potential cost of failed auctions at 300 milliseconds post trade to be $0.00046 per share, considerably less than their $0.0015 to $0.0047 per share estimate of the benefits from the proposed change in market structure. At 300 milliseconds, we find that quotes move against the retail trader for more than 19% of the shares in executed orders and the amount of movement equals or exceeds $0.0174 per share – between 3.7x and 15.5x greater than the SEC's estimated benefit – for all three measures of quote slippage we employ (Midquote Slippage, Far Touch Slippage, and Trade Price to Far Touch Slippage). ***Our estimates of the potential costs to retail investors from failed auctions at 300 milliseconds significantly exceed the lower bound of the Commission's estimated benefit and, when we further consider the net price improvement provided by wholesalers in the current market structure, our cost estimates exceed the Commission's upper bound estimated benefit of the auction mandate. In other words, in several of the scenarios we examine the Commission's auction proposal has the potential of creating a net loss for retail investors even if one accepts the Commission's estimated benefit. We believe the Commission would reach similar conclusions if it used actual retail orders and our revised methodology to conduct their analysis of fade costs.***

In the next section, we describe our data, which consist of order and trade data for all marketable orders routed to one or more wholesalers during May 2022. In Section II, we outline our methodology. We follow the SEC and choose 25 milliseconds, 100 milliseconds, and 300 milliseconds as the times over which to measure quote slippage. To measure quote slippage, we take three approaches: Midquote Slippage, Far Touch Slippage (e.g., slippage in the National Best Offer (NBO) price for buy orders and slippage in the

[10] The second set of slippage estimates are estimated using the BJZZ-identified set of retail trades generated by the set of all marketable orders routed to one or more wholesalers in May 2022. We believe that the Commission's analysis examines changes in NBBO midpoints and uses trades as the unit of measurement to compute these percentages. So, for this set of comparisons we also use trades**. In the tables presenting our calculation of expected auction failure costs later in this paper, we report the percent of shares in orders/trades that experience adverse mark-outs as we are interested in calculating an expected cost per share**.

National Best Bid (NBB) bid price for sell orders), and Trade Price to Far Touch Slippage. The last measurement uses the price at which the wholesaler(s) actually execute the trade in the current market structure (thus giving the wholesaler(s) credit for price improvement and punishing them for price disimprovement) and implicitly assumes that retail investors must pay the full NBBO spread after auctions fail to execute their orders due to adverse NBBO movements during the auction period.[11] In Section III, we present our findings. Section IV contains our conclusions and recommendations.

I. Data.

Our sample contains nearly 41 million orders and over 53 million trades arriving/occurring in regular market hours (e.g., between 9:30am and 4:00pm eastern time). Our analysis requires a complement of order-receipt and trade time NBBO snapshots and post order/trade NBBO snapshots (referred to as mark-outs) at 25 milliseconds, 100 milliseconds, and 300 milliseconds. After imposing this requirement, we are left with a final sample of at least 40,612,424 orders and 52,935,438 trades (over 99.4% of the initial sample) in 10,086 names. Including all securities traded by retail investors is important as they frequently trade securities that are not randomly drawn from the universe of securities (as was the SEC's sample of 600 National Market Securities and exchange traded funds) on dimensions such as market capitalization, volatility, and liquidity – all dimensions that are likely correlated with the likelihood of auction failure.

There are 40,838,852 orders in the data (all of which are received in normal market hours). There are 40,612,424 observations with the required quotes to perform the analyses at the 25 millisecond slippage time level, 40,612,429 at the 100 millisecond level and 40,612,430 at the 300 millisecond level. There are 53,281,374 trades in the sample, 53,280,260 occur during regular market hours and 52,942,138 have the required quotes to perform the analyses. Table 1 provides some descriptive statistics regarding the orders

[11] Note that wholesalers are not allowed to internalize at this price by the proposed rule, so we assume that they simply fill the order on the exchange offering the NBBO (ignoring the potential for insufficient size at the quote to fill the order). Our analysis does not consider the potential liquidity fees that are often associated with executing marketable orders on exchanges or the cost of paying to execute orders that seek to trade more shares than are available at the NBB or NBO.

and quotes in our sample. Order-weighted variables take an order as a unit of observations. Trade-weighted variables take a trade as a unit of observation.

[Insert Table 1 about here.]

The average trade price is less than the average volume-weighted average execution price for orders, suggesting that there are more trades in low-priced securities. The share-weighted average execution price emphasizes the tendency for more trades (filled shares) in low-priced securities. The average width of the benchmark NBBO is similar for orders (13 cents) and for trades (11 cents). The share-weighted numbers find that the low-priced securities, which have many more shares traded in our sample, enjoy a much tighter quoted spread. The mean order size is 444 shares and, on average, 94% of ordered shares are filled.[12] Even though wholesalers supposedly handle retail order flow, there are some very large marketable orders. For our sample of orders, Battalio and Jennings (2022) document that over 80% of fully internalized orders and 45% of fully externalized trades receive size improvement. Not reported in Table 1, we find that 56.95% of the orders are buy orders and 54.77% of the trades originate from buy orders.

II. Methodology.

To be consistent with the Commission's analysis, we examine NBBO snapshots 25 milliseconds, 100 milliseconds, and 300 milliseconds after order receipt time (trade time) when examining quote slippage for marketable orders (marketable trades). We examine two measures of quote fading: changes in the quote midpoint (i.e., Midquote Slippage) and changes in the far touch (i.e., Far Touch Slippage). The far touch is the NBO price for buy orders and the NBB price for sell orders. In addition, we compare the actual transaction price to the "faded" far touch quote (i.e., Trade Price Slippage). This is done in conjunction with the far touch fade analysis and recognizes the net price improvement that wholesalers offer in the current market structure. Thus, we compute the following slippage measures for each set of lagged mark-out quotes:

[12] Almost all of unexecuted shares are marketable limit orders. In those cases, the market moved to make the order non-marketable before the order filled.

- *Midquote Slippage = (Midpoint of mark-out NBBO – Midpoint of benchmark NBBO) x Indicator Variable*.
- *Far Touch Slippage = (Mark-out far touch – Benchmark far touch) x Indicator Variable.*
- *Trade Price Slippage = (Mark-out far touch – Trade price) x Indicator Variable*.

For each of the three slippage measures, the *Indicator Variable* equals +1 for buy orders and -1 for sell orders. In each of the three cases, a positive number indicates a potential cost to a failed auction and a negative number indicates a potential benefit of the failed auction.

We first compute these nine statistics (three quote slippage intervals and three cost metrics) for **marketable retail orders**. In this analysis, we benchmark mark-out quotes to order receipt time quotes. As noted earlier, since this is the time to which wholesalers are held in the execution quality analyses mandated by SEC Rule 605, this is the proper benchmark. However, to be comparable to the SEC's analysis, we also examine the wholesaler(s) trades using the Boehmer et al (2021) methodology. This involves measuring the sub-penny component of trade prices. The sub-penny increment is the decimal component of the trade price after stripping away the cents component. Thus, a trade at a price of $100.0199 has a sub-penny component of 99. Boehmer et al (2021) argue that the sub-penny increment of trade prices is associated with the likelihood that the trade originates from a retail investor.

Trades on the full penny (sub-penny increment of zero) and trades with prices having a sub-penny increment between 0.4 and 0.6 are not classified as retail trades by the BJZZ algorithm. Boehmer et al. (2021) argue that these trades are less likely to be from retail investors in the current market structure. We diverge from the SEC's analysis in that we focus entirely on the data-providing wholesaler(s)' trades as we know that they are all considered retail.[13] We construct two samples from our wholesaler data. One sample contains the trades that would be identified as retail trades by BJZZ – trades with sub-penny increments that are not zero and not in the .4 to .6 range. For these trades, we follow BJZZ and infer the order side from

[13] The SEC considers all trades reported to the Trade Reporting Facility and measures the sub-penny component of the price. We diverge from the Boehmer et al (2021) methodology by including wholesaler(s) trades at price less than $1.00 in our analysis as we know that they are still considered retail trades.

the sub-penny increment.[14] We refer to this set of trades as BJZZ-identified retail trades. The other sample contains the actual retail trades that are in those sub-penny intervals, i.e., trades at the full penny and trades in the .4 to .6 range. Here, we use the actual order side. We refer to this set of retail trades as BJZZ-unidentified retail trades.[15]

In summary our analyses have three samples (all orders, retail trades identified by the BJZZ algorithm, and retail trades not identified by the BJZZ algorithm), three time intervals for NBBO quote slippage (25 milliseconds, 100 milliseconds, and 300 milliseconds) and three measures of quote slippage (Midquote, Far Touch, and Trade Price) for a total of 27 analyses.

III. Results.

We report our basic results in three tables that differ by the quote slippage interval. Again, we use 25 milliseconds, 100 milliseconds, and 300 milliseconds to be consistent with the SEC's analysis. In each table, we report our results using the three samples (all marketable orders, BJZZ-identified retail trades, and BJZZ-unidentified retail trades) and applying three measures of quote slippage (Midquote, Far Touch, and Trade Price). Consistent with the Commission's analysis, we focus on the instances where the quote slippage works against the original retail investor (i.e., the benchmark price moves higher for a buy order or moves lower for a sell order). When using orders (trades), we start the clock on the quote slippage interval at order receipt (trade) time. Based on the SEC's proposal, it is our understanding that the Commission's fade analysis uses trades reported to the TRF (trade reporting facility) in 600 randomly selected NMS stocks and exchange traded funds identified as retail by the BJZZ algorithm and uses differences in the midpoint of the trade time NBBO and the mark-out NBBO to estimate slippage costs.

[Insert Table 2 about here.]

[14] Battalio et al. (2022) examine the accuracy of the BJZZ algorithm and find that it assigns the correct order side for over 93% of their sample of actual retail trades. See "Identifying Market Maker Trades as 'Retail' from TAQ: No Shortage of False Negatives and False Positives," by Robert Battalio, Robert Jennings, Mehmet Saglam, and Jun Wu. Available upon request.

[15] Because of the limited amount of time to comment on this rule proposal, we are unable to analyze a fourth set of trades: trades in the NYSE's TAQ database that are reported to a trade reporting facility in May 2022 that are identified as retail trades by the BJZZ-algorithm.

Table 2 presents results obtained using 25 millisecond mark-out quotes. In column 2 of Panel A, we present the percentage of marketable shares in orders that have mark-out quotes that move ***against*** the retail investor. The midpoint of the NBBO moves against the retail investor in the 25 milliseconds following the receipt of marketable orders by one or more wholesalers for 13.46% of the shares in sample of executed marketable orders. We find that there is an adverse quote movement in the far touch over this time interval for 11.04% of the executed shares generated by marketable orders. Finally, when comparing the trade price to the signed far touch prevailing 25 milliseconds after orders are received by wholesaler(s) reveals that when the price improvement provided by wholesalers is factored in, 9.17% of the shares in executed orders encounter adverse quote movements. Column 3 of Panel A presents the per share cost, as measured by the quote movement over 25 milliseconds, of failed auctions for orders that experience adverse quote fades. The potential costs associated with participating in failed auctions ranges from $0.0112 per share (Midquote Slippage) to $0.0198 per share (Trade Price Slippage), all of which exceed the SEC's assumed quote movement of $0.01 per share. These results are surprising since they are obtained using 25 millisecond mark-out quotes, which are of much shorter duration than the Commission's expected duration of the quickest auctions. Finally, column 4 presents the total potential cost of quote fades that move against the retail investor (per share cost times the number of shares with adverse quote movements) for our sample of retail marketable orders in May 2022. The total costs range from $25.6 million (Midquote Slippage) to $32.7 million (Trade Price Slippage).

Panels B and C of Table 2 are set up analogously to Panel A in that they report the percentage of shares in executed orders that have adverse quote moves, the per share potential cost of adverse quote moves, and the total potential cost of adverse quote moves for each of the three measures of fade costs. Panel B presents these statistics for BJZZ-unidentified retail trades (e.g., retail trades in our proprietary dataset that **are not** classified as retail trades by the BJZZ algorithm) and Panel C presents these statistics for BJZZ-identified retail trades (e.g., retail trades in our proprietary dataset that **are** classified as retail trades by the BJZZ algorithm).

An inspection of Panels A through C of Table 2 reveals that on a per share basis, ***it is less likely that 25 millisecond mark-out quotes measured after trades execute move against the retail investor than 25 millisecond mark-out quotes measured after orders are received by one or more wholesaler(s)***. For each of the three measures of fade costs, the percentage of shares impacted by adverse quote moves is larger when orders are used in the analysis than when either BJZZ-identified or BJZZ-unidentified trades are used. ***Independent of the measure used, the average per share potential fade costs using trades is highest for executed shares in the set of BJZZ-unidentified trades and is lowest for executed shares in the set of BJZZ-identified trades.*** The average per share cost of fades computed using all marketable orders routed to one or more wholesalers in May 2022 lies between the BJZZ-unidentified and the BJZZ-identified per share estimates.

The percentage of shares in BJZZ-identified trades for which the 25 millisecond mark-out quote moves against the retail investor is 9.50%. This compares to the SEC's estimate of 1.8% percent of trades moving against the retail investor at 25 milliseconds. There are at least two potential reasons for this (large) difference. First, our BJZZ-identified trades do not contain false positives (e.g., institutional trades executed on sub-pennies and reported to the TRF) – they only include trades resulting from marketable orders placed by actual retail investors. Second, our BJZZ-identified trades are in the symbols actually traded by retail investors in May 2022, not in 600 randomly selected symbols. Regardless, the SEC's estimate of 1.8% is less than one-fifth of the estimate obtained for either the BJZZ-identified or the BJZZ-unidentified set of retail trades' midpoint slippage.

Panel D of Table 2 presents the ***expected*** per share potential costs of failed auctions. ***Following the SEC's methodology, for each set of fade measures and datasets, we multiply the percentage of shares in executed marketable orders (trades) with adverse mark-out quote movements by the average per share potential cost of adverse quote movements***.[16] So, to obtain the expected per share potential costs of failed

[16] We believe that the SEC multiplied the percent of orders harmed by the assumed one penny of harm. For our order analysis, we find that it is more likely that large orders are disadvantaged so that the percent of shares exceeds the percent of orders.

auction for our sample of marketable orders estimated using the Midquote Slippage measure of fade costs, we multiply 13.46% by $0.112, which equals $0.0015 per share. Note that this is equal to the lower bound of the Commission's estimate of the per share expected benefits of imposing auctions on market participants and 3.26 times the Commission's estimate of per share failed auction costs at 300 milliseconds. When the far touch is used to compute potential fade costs, the expected per share cost of adverse fades rises to $0.0016 per share. Finally, when one considers the opportunity costs associated with foregone price improvement (from the wholesaler(s) for retail market orders pushed into failed auctions), the expected per share costs for orders rises to $0.0019 per share. A comparison of columns 2, 3 and 4 of Panel D reveal that per share expected fade costs computed using Midquote and Far Touch Slippage are highest for orders and are lowest for BJZZ-identified trades. Indeed, the difference in expected fade costs for orders and for BJZZ-identified trades is $0.0007 per share for the Midquote Slippage measure and is $0.0008 per share for the Far Touch Slippage measure.

Panel E of Table 2 contains annualized estimates of fade costs for the three different measures and the three different data sets. To compute the annualized estimates, we start with the consolidated volume of 798.58 billion shares traded in Q1 2022. Next, using wholesaler Rule 605 reports for Q1 2022, we determine that retail trading volume is about 17.41 percent of total volume. As Rule 605 reports do not include odd lots or short sales, this estimate is likely to be lower than the true percentage of retail trading volume. Next, we multiply the expected per share potential fade costs computed using data from May 2022 by the estimated number of retail shares traded in Q1 2022 (which equals 798.58 billion shares x 0.1741) to arrive at an estimate of total fade costs in Q1 2022. Finally, we multiply this measure by 4 to arrive at an annualized estimate of downside fade costs.

For both the Midquote Slippage and the Far Touch Slippage measures of fade costs, the annualized estimate of total fade costs computed using all marketable orders routed to one or more wholesalers in May 2022 is nearly twice as high as the comparable estimate computed using BJZZ-identified trades. Furthermore, for each of these two measures, the estimate of annualized fade costs is higher for the BJZZ-unidentified set of trades than it is for the BJZZ-identified set of trades. Thus, fade costs are higher when

actual marketable orders and order receipt times are used to estimate the potential harm of failed auctions than when BJZZ-identified retail trades and trade times are used in the analysis. Moreover, for our sample, the algorithm appears to identify retail trades for which failed auctions will impose less harm (i.e., the estimated failed auction cost for the BJZZ-identified retail trades is less than the estimated cost of the BJZZ-unidentified trades).

[Insert Tables 3 and 4 about here.]

Page 111 of the Commission's rule proposal states that "Proposed Rule 615(c)(2) specifies that the time period for a qualified auction must be no shorter than 100 milliseconds (1/10th of a second) and no longer than 300 milliseconds (3/10ths of a second) after an auction message is provided for dissemination in consolidated market data." For this reason, we present expected fade costs using 100 millisecond mark-out quotes in Table 3 and we present expected fade costs using 300 millisecond mark-out quotes in Table 4. The structure of Tables 3 and 4 is identical to the structure of Table 2.

Footnote 178 of the SEC's rule proposal states that "… the fade probability of the NBBO prices goes from an average of 1.8% at 25 milliseconds after an internalized individual investor order, to 2.8% at 100 milliseconds, and to 4.6% at 300 milliseconds...". Examining the second column of Panel A in Tables 2, 3 and 4 reveals that the percentage of executed shares in marketable orders for which the midquote moves against the retail investor rises from 13.46% at 25 milliseconds after order receipt time, to 19.22% at 100 milliseconds, and to 22.37% at 300 milliseconds. Possibly more consistent with the SEC's analysis, for our BJZZ-identified trades (Panel C, column 2 of Tables 2, 3 and 4), the fade probability computed using NBBO midpoints rises from 9.50% of executed shares at 25 milliseconds, to 11.87% of executed shares at 100 milliseconds, and to 15.18% of executed shares at 300 milliseconds. For each set of mark-out quotes, the fade probability computed using the Midpoint Slippage measure is higher for BJZZ-unidentified trades than it is for BJZZ-identified trades. Finally, for BJZZ-unidentified trades (Panel B, column 2), the fade probability computed using NBBO midpoints rises from 9.23% at 25 milliseconds, to 12.49% at 100 milliseconds, and to 16.32% at 300 milliseconds. For 100 and 300 millisecond mark-out quotes, the fade

probability computed using the Midpoint Slippage measure is higher for BJZZ-unidentified trades than it is for BJZZ-identified trades.

On page 290 of its auction proposal, the SEC notes that it uses $0.01 (or a tick) as its estimate of the amount of an adverse quote move. The third column of Panel A of Tables 2, 3 and 4 reveals the average per share cost for midquote moves against the retail investor computed using actual marketable orders executed by one or more wholesalers in May 2022 rises from $0.0112 per share at 25 milliseconds, to $0.0161 per share at 100 milliseconds, to $0.0174 at 300 milliseconds. Thus, the average adverse movement in the midquote starting when orders are received by wholesaler(s) exceeds $0.01 for even for the shortest time interval we examine.

As is the case with 25 millisecond mark-out quotes, when 100 millisecond mark-out quotes are used the percentage of shares involved in quote fades is higher when actual orders and order-receipt time quotes are used to compute slippage costs than when either BJZZ-identified or BJZZ-unidentified retail trades and execution-time quotes are used (see Panels A, B and C of Table 3). This, coupled with the fact that the average per share cost for fades that move against the investor are highest for actual orders for each of the measures, ***suggests that the use of inferred retail trades and trade times rather than actual retail orders and order receipt times significantly underestimates the potential harm of failed auctions – even at 25 milliseconds.***

Moving from 25 millisecond to 100 millisecond mark-out quotes increases the difference in the average per share cost of fades for orders and for BJZZ-identified trades for both the Midquote and the Far Touch Slippage measures. For example, using 25 millisecond mark-out quotes, the difference in the average per share cost for Midquote Slippage for orders and for BJZZ-identified trades is $0.0030. When 100 millisecond mark-out quotes are used, this difference is $0.0061. When 300 millisecond mark-out quotes are used, the difference in the average per share cost of Midquote Slippage for orders and for BJZZ-identified trades falls a bit to $0.0054 per share. It is interesting to note that the difference in per share fade costs estimates for orders and for BJZZ-identified retail trades ranges from 30% to 61% of a penny. Recall that the SEC uses an assumed adverse quote movement of $0.01 per share, which "the commission believes

it's the most frequent movement over a short time span."[17] ***For our sample of all marketable orders routed to one or more wholesalers in May 2022, we find that for orders, the average per share fade costs exceed $0.01 per share regardless of the difference between the time of the mark-out quote and the order receipt time and regardless of the measure of fade cost.*** Moreover, the ***difference*** in estimates obtained using orders and BJZZ-identified trades ranges from 30% to 61% of the baseline per share fade cost of $0.01 per share used by the SEC to compute the potential damages of failed auctions.

As a reminder, we compute expected fade costs by multiplying the percentage of shares in adversely affected orders or trades by the average per share fade cost. It is our understanding, based on reading of the SEC's rule proposal, that the SEC computes expected fade costs by multiplying the percentage of adversely affected BJZZ-identified retail trades in the TAQ data by $0.01 (the assumed modal per share adverse fade cost). The SEC concludes that the expected cost of adverse fades is less than $0.00046. ***The Commission's expected cost is significantly lower than the expected costs obtained for the set of all retail marketable orders sent to one or more wholesalers in May 2022 regardless of the measure we use to measure the cost of adverse quote moves.*** For example, using Midquote Slippage to measure expected per share fade costs in our order analysis, we find that expected costs of $0.0015 per share, $0.0031 per share, and $0.0039 per share for mark-out quotes of 25 milliseconds, 100 milliseconds, and 300 milliseconds respectively. ***Thus, expected fade costs for orders measured using Midquote Slippage are 3.26 to 8.48 times larger than the SEC's estimate. Indeed, even for our sample of BJZZ-identified retail trades generated by our sample of retail marketable orders, the expected per share fade costs measured using Midquote Slippage are 1.74 (25 millisecond mark-out quotes) to 3.91 (300 millisecond mark-out quotes) times larger than the SEC's estimate***.

Consistent with the Commission's analysis, our estimate of the expected costs of failed auctions obtained using the Midquote Slippage measure for BJZZ-identified retail trades is below the lower bound of the SEC's estimated benefits of auctions of $0.0015 per share at the 25 and 100 millisecond intervals.

[17] See page 290 of the SEC's auction rule proposal.

This is not true, however, for estimates of per share Midquote Slippage costs obtained for actual retail orders, which range from $0.0015 per share with 25 millisecond mark-out quotes to $0.0039 per share with 300 millisecond mark-out quotes. It also is not true for estimates of per share Midquote Slippage costs obtained for BJZZ-unidentified retail trades, which are $0.0019 per share with 100 millisecond mark-out quotes and $0.0028 per share with 300 millisecond mark-out quotes. Thus, our estimates suggest that it is likely that the costs of failed auctions exceed the Commission's lower bound estimate of benefits of successful auctions. ***And, this ignores the price improvement that is routinely provided to over 83.7% of fully internalized marketable retail orders by wholesalers in the current market structure, which would be lost if the auction proposal is adopted.***[18]

In Table 4, which employs a 300 millisecond mark-out time consistent with the SEC's maximum auction length, each of the nine measures of expected potential per share harm from the auctions exceeds the Commission's lower bound estimated benefit of the proposed auctions. When considering the net price improvement provided by wholesalers in the current market structure, our expected cost estimate exceeds the Commission's estimated upper bound benefit. ***On page 10 of the rule proposal, the Commission estimates that there is an annualized "competitive shortfall" of $1.5 billion in the current market structure. With the exception of the BJZZ-identified sample estimates that ignore net price improvement, each of our annualized estimates of potential failed auction costs exceed this estimate. In fact, each of the annualized estimates computed using order-receipt-time quotes as the benchmark instead of trade-time quotes greatly exceed $2 billion.***

IV. Conclusions & Recommendations.

In this paper, we use all marketable retail orders routed to one or more wholesaler(s) in May 2022 to evaluate the Commission's estimates of the potential costs of failed auctions in its proposed Order Competition Rule. To our surprise, the SEC utilizes an algorithm known to have both type I errors (e.g., falsely identify institutional trades as retail) and type II errors (e.g., identify only a subset of actual retail

[18] See Table 2 of Battalio and Jennings (2022).

trades) to classify trades that the NYSE's publicly available TAQ database shows were reported to a Trade Reporting Facility (e.g., a TRF) to conduct their analysis. Why are we surprised? On page 220 of the proposed rule the Commission explains in great detail why they use CAT data to supplement their analysis of execution quality that was initially conducted using Rule 605 execution quality statistics. The commission writes,

> "Because Rule 605 requires market centers to report execution quality statistics only for covered orders that fall within specific order size and type categories, ***a number of order types and sizes that may be particularly relevant for individual investors are excluded from the above analyses, including orders for less than 100 shares.*** Additionally Rule 605 data ***does not allow us to distinguish between orders that wholesalers execute on a principal basis from those they execute on riskless principal basis, since they are both reported as being executed at the market center.*** Furthermore***, it is not possible in Rule 605 data to distinguish between orders that a wholesaler received from individual investors from those it received from other types of market participants.*** For example, wholesaler Rule 605 reports may include both individual investor orders that they receive, as well as institutional orders they receive on their SDPs. Lastly, effective and realized spread measures as required to be reported in Rule 605 reports are calculated using a five-minute time horizon, which some academic literature argues has become inappropriate for a high-frequency environment. Therefore***, to supplement the analyses using Rule 605 data and test for the robustness of the results that it generated, CAT data was analyzed to look at the execution quality of marketable orders of individual investors in NMS Common Stocks and ETFs that were less than $200,000 in value and that executed and were handled by wholesalers during Q1 2022*** ("CAT retail analysis")." – ***Emphasis added.***

The SEC provides several reasons why they use CAT data to supplement their Rule 605 analysis of wholesaler execution quality. They note that the Rule 605 data do not include odd lots, the Rule 605 data do not differentiate between retail trades executed by wholesalers on a principal and on a riskless principal basis, and they don't distinguish between orders that a wholesaler receives from individual investors and orders they receive from other types of market participants. The SEC acknowledges that by using the BJZZ algorithm to classify trades as retail, they are only capturing about 35% of marketable retail trades (see footnote 572). Also, in footnote 572, the Commission writes that "plausibly a significant fraction of the retail trades unidentified by the algorithm reflects orders executed on a risk-less principal basis, i.e., executions that would not be relevant to the order flow targeted by the Proposal." Battalio et al. (2022) show that the BJZZ algorithm has both type I and type II errors. That is, the algorithm fails to classify actual retail trades as retail and it incorrectly classifies institutional 'child' trades as retail trades. Using a sample

of TAQ trades identified as retail trades by the BJZZ algorithm to examine the potential costs of failed auctions seems to suffer from some of the same flaws as using a sample of Rule 605 statistics to evaluate wholesaler execution quality. It is not clear why the Commission chooses to use the more detailed and accurate CAT data to examine wholesaler execution quality but uses an admittedly incomplete data source for its examination of the potential adverse costs associated with their rule proposal.

To better understand the ramifications of utilizing an inferior dataset to examine the potential costs of failed auctions, we conduct an alternative 'fade analysis' ***using all marketable retail orders routed to one or more wholesalers in May 2022*** and adjusting several of the inputs used by the Commission to estimate the potential costs of failed auctions. To more accurately capture the potential costs associated with adverse quote movements during failed auctions, our primary analysis utilizes a dataset of ***all marketable retail orders (regardless of symbol) routed to one or more wholesalers in May 2022***. The Commission focuses their analysis on trades in a random sample of 600 NMS securities and exchange traded funds, and thus is likely not focused on the assets that retail investors actually trade. ***The primary benefit of using orders rather than trades as the primary unit of analysis is that auctions will commence when retail orders arrive at an exchange, not when trades are reported to the market via the Consolidated Tape***. There is no reason to expect the movement in the NBBO after an order is received by a trading venue (a non-public event) will be the same as the movement of in the NBBO after a trade (a publicly reported event). The use of order data allows us to examine movements in the NBBO that begin when orders are received. Because the Commission uses trades in their analysis, they have no choice but to examine movements quotes after trades are reported. ***Our use of order receipt time quotes to evaluate potential fade costs is consistent with the SEC's requirement that order receipt time quotes be used to create the execution quality statistics that trading venues must publish in monthly Rule 605 reports and produces higher estimates of failed auctions than those obtained using trade time quotes.***

To better understand the differences between a fade analysis conducted using orders and order receipt times and one that uses trades and trade times, we conduct modified fade analyses on two additional sets of trades: retail trades generated by our sample of marketable retail orders that would be identified as

retail trades by the BJZZ algorithm (similar to the Commission's analysis) and retail trades in our sample of marketable retail orders that would not be identified as retail trades by the BJZZ algorithm. By construction, our BJZZ-identified retail trades are actual retail trades (e.g., there are no false positives). ***Given the short time to comment on this proposal, we were not able to conduct a fourth fade analysis on a dataset of all TAQ trades identified as retail by the BJZZ algorithm in May 2022. Such a dataset would contain a subset of actual retail trades identified by the BJZZ algorithm as retail trades as well as a subset of institutional trades identified by the BJZZ algorithm as retail trades.***

In order to address the shortcomings in the SEC's analysis, we make several modifications in order to more accurately measure affected shares and costs and augment the SEC's methodology to provide important additional perspectives. First, rather than use $0.01 as cost of an adverse quote movement when computing expected per share fade costs, we use the actual average per share amount of the adverse quote movement. Second, rather than using the percentage of orders or trades that experience an adverse quote movement to compute expected per share fade costs, we use the percentage of shares in executed orders or trades that experience an adverse quote movement. Third, we measure quote slippage from order receipt time in addition to trade execution time. Finally, in addition to using adverse movements in the midpoint of the NBBO to estimate the potential costs of failed auctions, we use movements in the far touch as well as the signed difference in execution prices and the far touch to provide a more complete picture of the potential costs of failed auctions. Our examination of movements in the far touch addresses the potential criticism that movements in the NBB (NBO), which will cause movements in the quote midpoint, may not be a concern for marketable buy (sell) orders that participate in failed auctions. Our examination of differences in the trade price and the far touch considers the fact that marketable orders that participate in failed auctions would have, with some probability, received net price improvement in the current market structure.

Our primary findings are as follows:

- On a per share basis, it is **less likely** that 25 millisecond mark-out quotes measured after BJZZ-identified retail trades execute move against the retail investor than 25 millisecond mark-out quotes measured after retail orders are received by one or more wholesaler(s) (9.50% of shares versus 13.46% of shares, respectively).
- ***For BJZZ-identified retail trades***, the fade probability computed using NBBO midpoints rises from 9.50% of executed shares at 25 milliseconds, to 11.87% of executed shares at 100 milliseconds, and to 15.18% of executed shares at 300 milliseconds when we consider all securities traded by our cooperating wholesaler(s). ***The percentage of executed shares in marketable orders*** for which the midquote moves against the retail investor rises from 13.46% at 25 milliseconds after order receipt time, to 19.22% at 100 milliseconds, and to 22.37% at 300 milliseconds. This compares to ***SEC fade probabilities*** of 1.8% at 25 milliseconds, to 2.8% at 100 milliseconds, and to 4.6% at 300 milliseconds estimated using a sample of trades in the NYSE's TAQ database in 600 randomly selected NMS securities and exchange traded funds that the BJZZ algorithm identified as being retail trades.
- ***The average downside movement in the midquote starting when orders are received by wholesaler(s) exceeds the SEC's assumed $0.01 for even for the shortest failed auctions.***
- Expected fade costs for orders measured using Midquote Slippage are 3 to 7.8 times larger than the SEC's estimate.
- ***Expected fade costs for our sample of BJZZ-identified retail trades generated by our sample of retail marketable orders measured using Midquote Slippage are 1.6 (25 millisecond mark-out quotes) to 3.6 (300 millisecond mark-out quotes) times larger than the SEC's estimate.***
- Our analysis of all marketable retail orders routed to one or more wholesalers in May 2022 suggests that the potential per share cost of failed auctions exceeds lower bound estimates of the per share potential benefits of successful auctions.

- When lost net price improvement is factored into the potential cost of failed auctions, the potential costs of failed auctions using 300 millisecond mark-out quotes are higher than the upper bound estimate of the potential benefits of successful auctions.
- ***With the exception of the BJZZ-identified sample estimates that ignore net price improvement, each of our annualized estimates of potential failed auction costs using mark-out quotes of 100 300 milliseconds (the Commission's minimum and maximum expected auction lengths) exceed the Commission's annualized estimate of the competitive shortfall of $1.5 billion in the current market structure.***
- ***Each of the estimates of the potential aggregate cost of failed auctions computed using order-receipt-time quotes as the benchmark instead of trade-time quotes at the SEC's maximum auction duration of 300 milliseconds generate annualized costs greatly exceed $2 billion.***

To summarize, we are puzzled by the fact that the SEC utilized an inferior dataset to examine the potential cost of failed auctions when they possess a superior set of data (the CAT data). For our sample of marketable retail orders routed to one or more wholesalers in May 2022, we find that potential fade costs are significantly higher when orders (and order receipt times) are used in the analysis. This is true when our results are compared to similar estimates in the SEC's rule proposal and when they are compared to similar estimates for BJZZ-identified retail trades in our dataset. ***Our results suggest that the potential costs of failed auctions are of the same order of magnitude as the Commission's estimated potential benefits of successful auctions.*** Given our results and the high degree of uncertainty as to how the Commission's Order Competition Proposal will impact equity markets, we suggest the Commission table this rule proposal. As we wrote in our 2016 paper, "Can Brokers Have it all? On the Relation between Make-Take Fees and Limit Order Execution Quality" written with Shane Corwin, we believe the rule changes contained in the Commission's proposed Disclosure of Order Execution Information rule will go a long way toward eliminating ***any*** inefficiencies in the market for marketable retail orders.

Finally, while we believe the Commission's analysis of fade costs can be improved on several dimensions, we expect our analysis could also be improved by allowing other academics, market participants, and regulators to provide feedback on our work. Unfortunately, the window given by the Commission to provide comments on the four proposals introduced in December 2022 does not allow us the opportunity to solicit the feedback that is typically given to academic work. We plan to post a version of this 'paper' on SSRN and will update the paper if we receive material feedback.

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Table 1. Descriptive statistics for marketable orders routed to one or more wholesalers in May 2022.

Panel A. Order-weighted statistics.

Variable	Mean	Minimum	Maximum
Order receipt time NBB price	$142.44	$0.0003	$4,668.15
Order receipt time NBO price	$142.57	$0.0004	$4,686.47
Volume-weighted average trade price	$142.51	$0.0003	$4,668.15
Order size (shares)	444	1	3,413,000
Executed size (shares)	418	0	2,081,000

Panel B. Trade-weighted statistics (using the 52,943,208 trades with complete data).

Variable	Mean	Minimum	Maximum
Trade time NBB price	$124.00	$0.0062	$4,668.16
Trade receipt time NBO price	$124.11	$0.0067	$4,686.47
Trade price	$124.06	$0.0003	$4,681.47
Executed size (shares)	321	1	500,000

Panel C. Share-weighted statistics (using the 52,943,208 trades with complete data).

Variable	Mean	Minimum	Maximum
Trade time NBB price	$38.17	$0.0062	$4,668.16
Trade receipt time NBO price	$38.19	$0.0067	$4,686.47
Trade price	$38.18	$0.0003	$4,681.47

Table 2. Adverse fade costs for failed auctions estimated using 25 millisecond mark-out quotes.

We begin with all marketable orders received by one or more wholesalers in May 2022. There are 40,612,424 marketable orders for which quote benchmarks and mark-out quotes are available for the order. We require mark-out quotes be available in 25 millisecond intervals following the receipt of an order (e.g., time t) beginning with t + 25 milliseconds and ending with t + 300 milliseconds. We examine three measures of slippage: *Midquote Slippage, Far Touch Slippage,* and *Trade Price Slippage*. *Midquote Slippage* is defined as the difference of the order receipt time quote midpoint and the midpoint of the subsequent mark-out quote. For buy (sell) orders, *Far Touch Slippage* is defined as the difference between the order receipt time ask (bid) and the mark-out ask (bid). For buy (sell) orders, *Trade Price Slippage* is defined as the difference between the trade price and the mark-out ask (bid). For buy (sell) orders, we define an increase in the quote benchmark as a positive (negative) cost and a decrease in the quote benchmark as a negative (positive) cost. Consistent with the SEC's fade analysis in its 'Order Competition Rule' proposal, we focus on the potential costs of failed auctions.

Panel A. 40,612,424 wholesaler orders in May 2022 with 25 millisecond mark-out quotes.

25 millisecond fade cost measure vs. order-receipt time NBBO	% of executed shares in orders for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	13.46%	$0.0112	$25,611,694
Far Touch Slippage	11.04%	$0.0142	$26,605,027
Trade Price Slippage	9.17%	$0.0198	$32,707,095

Panel B. 36,312,498 BJZZ-unidentified retail trades in May 2022. 68.6% of wholesaler trades in May 2022 are unidentified and have 25 millisecond mark-out quotes.

25 millisecond fade cost measure vs. trade-time NBBO	% of shares in unidentified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	9.23%	$0.0133	$13,350,685
Far Touch Slippage	6.99%	$0.0184	$14,020,080
Trade Price Slippage	7.98%	$0.0357	$31,019,220

Panel C. 16,629,640 BJZZ-identified retail trades in May 2022. 31.4% of wholesaler trades in May 2022 are unidentified and have 25 millisecond mark-out quotes.

25 millisecond fade cost measure vs. trade time NBBO	% of shares in identified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	9.50%	$0.0082	$4,792,797
Far Touch Slippage	6.32%	$0.0127	$4,904,940
Trade Price Slippage	7.38%	$0.0190	$8,598,392

Table 2 (continued).

Panel D. The expected per share fade costs for all orders, BJZZ-unidentified trades, and BJZZ-identified trades with adverse 25 millisecond mark-out quote movements. Following the SEC's methodology, the expected cost is computed by multiplying the probability that an order/trade has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes.

25 millisecond fade cost measure vs. trade time NBBO	Executed shares in orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0015	$0.0012	$0.0008
Far Touch Slippage	$0.0016	$0.0013	$0.0008
Trade Price Slippage	$0.0019	$0.0028	$0.0014

Panel E. Overall annualized 2022 downside fade costs using 25 millisecond mark-out quote movements, assuming 798.58 billion shares trade in total and that 17.41% of that volume is retail. The expected cost is computed by multiplying the probability that a share has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes. The annualized estimate is computed by multiplying the product of the estimated retail volume in Q1 2022 and the expected per share cost by four.

25 millisecond fade cost measure vs. trade time NBBO	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.841 B	$0.686 B	$0.435 B
Far Touch Slippage	$0.875 B	$0.718 B	$0.448 B
Trade Price Slippage	$1.071 B	$1.590 B	$0.782 B

Table 3. Adverse fade costs for failed auctions estimated using 100 millisecond mark-out quotes.

We begin with all marketable orders received by one or more wholesalers in May 2022. There are 40,612,424 marketable orders for which quote benchmarks and mark-out quotes are available for the order. We require mark-out quotes be available in 25 millisecond intervals following the receipt of an order (e.g., time t) beginning with t + 25 milliseconds and ending with t + 300 milliseconds. We examine three measures of slippage: *Midquote Slippage, Far Touch Slippage,* and *Trade Price Slippage*. *Midquote Slippage* is defined as the difference of the order receipt time quote midpoint and the midpoint of the subsequent mark-out quote. For buy (sell) orders, *Far Touch Slippage* is defined as the difference between the order receipt time ask (bid) and the mark-out ask (bid). For buy (sell) orders, *Trade Price Slippage* is defined as the difference between the trade price and the mark-out ask (bid). For buy (sell) orders, we define an increase in the quote benchmark as a positive (negative) cost and a decrease in the quote benchmark as a negative (positive) cost. Consistent with the SEC's fade analysis in its 'Order Competition Rule' proposal, we focus on the potential costs of failed auctions.

Panel A. 40,612,429 wholesaler orders in May 2022 with 100 millisecond mark-out quotes.

100 millisecond fade cost measure vs. order-receipt time NBBO	% of executed shares in orders for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	19.22%	$0.0161	$52,744,952
Far Touch Slippage	16.83%	$0.0200	$57,236,599
Trade Price Slippage	16.73%	$0.0197	$55,909,820

Panel B. 36,312,498 BJZZ-unidentified retail trades in May 2022. 68.6% of wholesaler trades in May 2022 are unidentified and have 100 millisecond mark-out quotes.

100 millisecond fade cost measure vs. trade-time NBBO	% of shares in unidentified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	12.49%	$0.0150	$20,425,779
Far Touch Slippage	9.89%	$0.0201	$21,641,771
Trade Price Slippage	11.19%	$0.0342	$41,598,266

Panel C. 16,629,640 BJZZ-identified retail trades in May 2022. 31.4% of wholesaler trades in May 2022 are unidentified and have 100 millisecond mark-out quotes.

100 millisecond fade cost measure vs. trade time NBBO	% of shares in identified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	11.87%	$0.0100	$7,242,912
Far Touch Slippage	8.58%	$0.0145	$7,601,617
Trade Price Slippage	9.80%	$0.0194	$11,655,606

Table 3. (continued)

Panel D. The expected per share fade costs for all orders, BJZZ-unidentified trades, and BJZZ-identified trades with adverse 100 millisecond mark-out quote movements. The expected cost is computed by multiplying the probability that an order/trade has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes.

100 millisecond fade cost measure vs. trade time NBBO	Executed shares in orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0031	$0.0019	$0.0012
Far Touch Slippage	$0.0037	$0.0020	$0.0012
Trade Price Slippage	$0.0033	$0.0038	$0.0019

Panel E. Overall annualized 2022 downside fade costs using 100 millisecond mark-out quote movements, assuming 798.58 billion shares trade in total and that 17.41% of that volume is retail. The expected cost is computed by multiplying the probability that a share has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes. The annualized estimate is computed by multiplying the product of the estimated retail volume in Q1 2022 and the expected per share cost by four.

100 millisecond fade cost measure vs. trade time NBBO	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$1.727 B	$1.046 B	$0.662 B
Far Touch Slippage	$1.878 B	$1.109 B	$0.694 B
Trade Price Slippage	$1.839 B	$2.136B	$1.061 B

Table 4. Adverse fade costs for failed auctions estimated using 300 millisecond mark-out quotes.

We begin with all marketable orders received by one or more wholesalers in May 2022. There are 40,612,424 marketable orders for which quote benchmarks and mark-out quotes are available for the order. We require mark-out quotes be available in 25 millisecond intervals following the receipt of an order (e.g., time t) beginning with t + 25 milliseconds and ending with t + 300 milliseconds. We examine three measures of slippage: *Midquote Slippage, Far Touch Slippage,* and *Trade Price Slippage*. *Midquote Slippage* is defined as the difference of the order receipt time quote midpoint and the midpoint of the subsequent mark-out quote. For buy (sell) orders, *Far Touch Slippage* is defined as the difference between the order receipt time ask (bid) and the mark-out ask (bid). For buy (sell) orders, *Trade Price Slippage* is defined as the difference between the trade price and the mark-out ask (bid). For buy (sell) orders, we define an increase in the quote benchmark as a positive (negative) cost and a decrease in the quote benchmark as a negative (positive) cost. Consistent with the SEC's fade analysis in its 'Order Competition Rule' proposal, we focus on the potential costs of failed auctions.

Panel A. 40,612,430 wholesaler orders in May 2022 with 300 millisecond mark-out quotes.

300 millisecond fade cost measure vs. order-receipt time NBBO	% of executed shares in orders for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	22.37%	$0.0174	$66,229,438
Far Touch Slippage	19.63%	$0.0213	$71,083,586
Trade Price Slippage	19.71%	$0.0232	$77,676,161

Panel B. 36,312,498 BJZZ-unidentified retail trades in May 2022. 68.6% of wholesaler trades in May 2022 are unidentified and have 300 millisecond mark-out quotes.

300 millisecond fade cost measure vs. trade-time NBBO	% of shares in unidentified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	16.32%	$0.0171	$30,418,657
Far Touch Slippage	13.31%	$0.0220	$31,820,398
Trade Price Slippage	15.09%	$0.0362	$59,320,675

Panel C. 16,629,640 BJZZ-identified retail trades in May 2022. 31.4% of wholesaler trades in May 2022 are unidentified and have 300 millisecond mark-out quotes.

300 millisecond fade cost measure vs. trade time NBBO	% of shares in identified trades for which mark-out NBBO ***moves against investor***	Average Per Share Cost for fades that ***move against investor***	Total cost of fades that ***move against investor***
Midquote Slippage	15.18%	$0.0120	$11,172,723
Far Touch Slippage	11.33%	$0.0017	$11,579,690
Trade Price Slippage	12.88%	$0.0211	$16,609,090

Table 4. (Continued)

Panel D. The expected per share fade costs for all orders, BJZZ-unidentified trades, and BJZZ-identified trades with adverse 300 millisecond mark-out quote movements. The expected cost is computed by multiplying the probability that an order/trade has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes.

300 millisecond fade cost measure vs. trade time NBBO	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0039	$0.0028	$0.0018
Far Touch Slippage	$0.0042	$0.0029	$0.0019
Trade Price Slippage	$0.0046	$0.0055	$0.0038

Panel E. Overall annualized 2022 downside fade costs using 300 millisecond mark-out quote movements, assuming 798.58 billion shares trade in total and that 17.41% of that volume is retail. The expected cost is computed by multiplying the probability that a share has an adverse mark-out quote times the average per share fade costs for orders with adverse mark-out quotes. The annualized estimate is computed by multiplying the product of the estimated retail volume in Q1 2022 and the expected per share cost by four.

300 millisecond fade cost measure vs. trade time NBBO	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified trades for which mark-out NBBO ***moves against investor***	BJZZ-identified trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$2.172 B	$1.558 B	$1.017 B
Far Touch Slippage	$2.333 B	$1.634 B	$1.056 B
Trade Price Slippage	$2.552 B	$3.048 B	$1.517 B