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August 4, 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 revised copy of our 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., instances when the NBBO moves against the investor during the proposed auction period) on retail execution quality. Following discussions with Commission Staff and others, we have expanded our analysis along three dimensions.

- First, we added a fade analysis conducted using trades in the NYSE's Trade and Quote database identified as retail by the algorithm introduced by Boehmer et al. (2021). This analysis allows us to more closely examine the implications of the Commission's decision to use 'inferred' retail trades rather than actual retail orders in their analysis of potential fade costs.

- Second, the fade cost estimates in our prior draft should be interpreted as consistent with the wholesaler(s) sending ALL marketable order flow to a qualified auction. In our revised draft, we estimate potential auction costs after eliminating orders/trades for $200,000 notional value and greater from our sample.

- Third, we propose an alternative method for estimating the potential costs imposed on marketable limit orders that become nonmarketable during failed auctions.

We continue to find that the Commission's use of 'inferred' retail trades and execution-time quote benchmarks results in potential cost estimates that are significantly lower than those obtained when using actual retail orders and order receipt time quote benchmarks. While assuming that all orders currently exceeding $200,000 are not put into the proposed auctions does reduce the estimated fade costs, it still seems likely that fade costs will approach or exceed the lower bound of the estimated benefits of the proposal – benefits which the Commission admits are uncertain. In reasonable scenarios, we continue to 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.

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

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,

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This Draft: August 4, 2023

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

by

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Abstract: While the United States Securities and Exchange Commission (SEC) utilized their proprietary Consolidated Audit Trail data in its analysis of the potential benefits of the proposed Order Competition Rule (OCR), they instead chose to utilize an algorithm to infer potential retail trades in the publicly available Trade and Quote (TAQ) database to estimate the potential costs of the proposed rule. In this paper, we use a proprietary dataset of actual retail orders and the publicly available TAQ data to examine the implications of using inferred retail trades rather than actual retail orders to estimate the potential costs of the OCR. We present evidence suggesting the SEC's decision to use inferred retail trades rather than actual retail orders produces significantly lower cost estimates than are obtained using actual orders. Using actual orders, our annualized cost estimates exceed the lower bound of the SEC's estimates of the benefits of the OCR. Based on this evidence, we recommend the SEC table the OCR.

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. We thank Charles Trzcinka and SEC staff members for comments on our prior draft. Any errors in this document are the responsibility of the authors.

On December 14, 2022, the Securities and Exchange Commission (SEC) proposed the Order Competition Rule (OCR) (Release number 34-96495, File number S7-31-22). This rule proposes prohibiting so called "restricted competition" trading venues (with some exceptions) from filling an order internally without first submitting the order to a qualified auction operated by a so called "open competition" trading center. Although the definition is somewhat broader, the restriction seems targeted at wholesalers who accept orders from retail brokers and sometimes make payments for the order flow if demanded by the broker.[1] Generally speaking, the open competition trading venues are the registered exchanges. The Commission posits that retail investors will receive better trade prices if marketable retail order flow is routed to an open competition trading center because a greater number of liquidity providers will vigorously compete on an order-by-order basis.

The SEC estimates that there is an annual "competitive shortfall" of between $1.12B and $2.30B in the current market structure that will be eliminated by the OCR, producing an estimated benefit of $0.0015 to $0.0047 per share for retail investors. These expected benefits are an order of magnitude higher than the Commission's estimates of the potential costs of failed auctions, which they suggest can be as high as $0.00046 per share. Although many comment letters argue that the SEC vastly overestimated the possible benefits,[2] we take the SEC's estimated benefits at face value and examine the validity of the Commission's expected cost estimates for retail orders involved in potentially failed auctions.

The SEC deployed different datasets and methodologies when it estimated the potential costs and the potential benefits of the OCR for retail investors. When estimating the proposed rule's potential benefits, the Commission utilized the proprietary Consolidated Audit Trail (CAT) data, which contains order data with the market participant type, e.g., retail, identified. These data allowed the Commission to be confident in identifying and studying retail order flow. For example, the Commission was able to benchmark retail

[1] The Order Competition Rule notes that over 90% of marketable retail orders were sent to the six largest wholesalers in the first quarter of 2022.

[2] See e.g., https://www.sec.gov/comments/s7-31-22/s73122-20164211-334052.pdf.

execution quality to order receipt time quotes. However, for the OCR cost analysis, the Commission chose to use the publicly available Trade and Quote (TAQ) data, which does not include participant type identifiers or order receipt times, and use an algorithm to infer which trades in the TAQ data should be included as retail in its analysis. Implicitly, by utilizing these inferred data, the Commission must 1.) be satisfied with using quotes matched to trade times even though market participants are held to order-receipt-time quotes for reporting execution quality in SEC Rule 605 reports and 2.) correctly infer which trades in the TAQ data are associated with retail orders.

The Commission used the algorithm proposed by Boehmer et al. (2021), hereafter, the BJZZ algorithm, to infer retail trades in the TAQ database. Boehmer et al. (2021) begin with the assumption that retail orders internalized by wholesalers are reported to a Trade Reporting Facility (TRF) on TAQ with the exchange code "D". Next, the authors note that wholesalers frequently print trades using sub-penny prices, i.e., with more than two decimal points in the price, and assert that market participants other than wholesalers who report trades to a TRF primarily provide trade prices at the full cent (i.e., zero sub-penny) or on the half-penny (i.e., a .5 sub-penny). To be conservative, the BJZZ algorithm classifies all trades printing between a sub-penny increment of .4 and .6 as "mid-quote" trades that are not the result of retail trading interest. Thus, all TAQ trades reported via the TRF with sub-penny prices greater than zero but not in the .4 to .6 interval are taken as retail trades. There is a considerable amount of academic work noting that the BJZZ methodology makes frequent Type I and Type II errors – falsely identifying non-retail trades as retail and failing to identify retail trades as retail.[3] Furthermore, because the original order data are not employed, BJZZ must infer order side (buy or sell) by the sub-penny increment – small increments above the National Best Bid are presumed to result from sell orders and small increments below the National Best Offer are presumed result from buy orders. After identifying allegedly retail trades using this algorithm, the Commission estimates how frequently the quoted price moves against the investor and then assumes the quote change is $0.01 when a fade occurs. This unexplained assumption is made despite the fact that the

[3] See e.g., Barber et al. (2022) and Battalio et al. (2022).

TAQ database provides the quotes at both trade time and any desired time post trade. The SEC concludes that the expected cost of adverse price movements during the proposed auctions is $0.00046 for auctions lasting 300ms – an order of magnitude smaller than the upper bound of their benefit estimate ($0.0015 to $0.0047 per share).

In our analysis below, we use a sample of actual retail orders from one or more wholesaler(s) in May 2022 to replicate (as best we can) the SEC's cost analysis. **We conclude that the potential expected cost per share of failed auctions is uniformly greater than the Commission's estimate of $0.00046 per share, frequently as large as the Commission's lower bound estimate of the proposed rule's benefit of $0.0015 per share, and potentially greater than the Commission's upper bound on benefit of $0.0047 per share.** Stated in total annual dollar terms, we estimate that the annual cost of the proposed rule to be $1.12B to $1.97B under the range of proposed auction lengths. Thus, simply more accurately assessing the cost of failed auctions eclipses the Commission's lower bound estimate of annual benefits ($1.12B) and, for some estimates of cost, approaches the upper bound of benefits ($2.3B).

Why do we and the Commission reach such different conclusions regarding the cost of failed auctions? The potential reasons are numerous but begin with the fact that, for our base case estimate, we assess quote fade costs relative to the order-receipt-time quote not the trade time quote. Although wholesaler trades generally happen quickly after order arrival, quotes also move quickly so delaying the measurement of quote fade by using the trade time makes the SEC's analysis less accurate and diminishes the cost estimate. **In addition, we find that the quotes move against the investor much more frequently than the Commission; by a factor of nearly five times at the 300ms level.** At least part of this difference is because we use the fraction of shares in disadvantaged orders to compute potential damages rather than follow the Commission's methodology and use the percentage of trades that are disadvantaged - if larger trades are more likely to move quotes, then the percent of shares disadvantages is larger than the percent of trades disadvantaged. We use shares as the unit of measurement throughout our analysis, i.e., for dollar cost measurement, to must make sure the units match (i.e., we cannot multiply the probability of a TRADE being adversely affected by an auction times the cost of being disadvantaged per SHARE). Relatedly, we

also measure the actual amount of quote fade (per share) and find that it frequently exceeds the $0.01 assumed by the Commission (even at an interval of 25ms after order arrival).[4] Finally, we document that the Boehmer et al. (2021) methodology does not seem to be unbiased in the trades identified. Using our sample of actual retail trades, the sub-sample of BJZZ identified trades consistently produces the lowest estimate of cost associated with the proposed rule, frequently one-half of that estimated from order data or the sub-sample of retail trades in our sample that are not identified by the algorithm.

We conclude that the Commission's methodology, which utilizes an inferior dataset and requires heroic assumptions, vastly underestimates the potential costs associated with the OCR. We conduct a more accurate assessment of the potential costs associated with failed auctions made using actual retail orders and assessing fade costs in the 100ms to 300ms following the receipt of orders by one or more wholesalers. The results of our analysis suggest the potential costs associated with order-by-order auctions are actually very close to the Commission's admittedly uncertain lower bound estimate of the benefits from the proposed rule. Indeed, in some plausible scenarios, estimates of potential fade costs approach and even exceed the upper bound of estimated benefits of the OCR as estimated by the Commission. With such an uncertain net positive benefit, we believe that the Order Competition Rule should be tabled.

I. Data.

We obtain all marketable orders from one or more wholesalers for May 2022.[5] 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) when the market is not crossed (i.e., when the NBB is not greater than the NBO). Our analysis requires a complement of order-receipt and trade time NBBO snapshots and post order/trade NBBO snapshots (referred to as mark-outs). We choose to examine quotes at 25 milliseconds, 100 milliseconds, and 300 milliseconds post order/trade to be consistent with the time intervals used by the Commission in their analysis. After imposing this requirement, we are left with a final sample of at least

[4] Again, just as larger orders/trades are more likely to cause a quote fade, they also are more likely to cause a quote fade greater than the Commission's assumed $0.01 fade.

[5] For brevity we refer to "one or more wholesalers" as wholesaler(s) in the remainder of the paper. The data provider(s) have more that 25% of the orders, shares, and executions among the six major wholesalers.

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.[6]

There are 40,838,852 orders in the data that 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.[7] There are 53,281,374 trades in the sample, 53,280,260 occur during regular market hours and 52,943,208 have the required quotes to perform the analyses. Table 1 provides some descriptive statistics regarding the orders and quotes in our sample. Panel A reports statistics taking an order as the unit of observation. Panel B (C) reports trade-weighted (share-weighted) numbers.

[Insert Table 1 about here.]

The mean trade-weighted price ($124.06) is less than the mean order-weighted execution price for orders ($142.51), suggesting that there are more trades in lower-priced securities. The share-weighted average execution price is much less ($38.18), which emphasizes the tendency for more filled shares in low-priced securities. Trade price is heavily skewed, with the mean roughly equal to the 75th percentile regardless of how one arranges the data (e.g., by orders, by trades, or by share count). The mean width of the benchmark NBBO is similar for orders (13 cents) and for trades (11 cents), but much tighter ($0.02)

[6] Based on our reading of the rule proposal, the SEC broke symbols into three groups – the top 500 by volume, the next 500 by volume, and the following 2000 by volume – and selected a stratified random sample of 200 symbols from each group. We ranked the symbols traded by the wholesaler(s) and all symbols listed on the Center for Research in Security Prices (CRSP) by volume for the sample month of May 2022 and formed analogous groups to determine the overlap. The wholesaler(s) trades all 500 symbols that are in the top 500 symbols by volume on CRSP but only 337 of them are in the 500 most-heavily-traded symbols by the wholesaler(s). The wholesaler(s) trades 497 of the second 500 symbols by volume on CRSP but only 139 are in the second 500 symbols traded by the wholesaler(s). Finally, less than one-half of the symbols in the CRSP 1001-3000 group by volume align with the wholesaler(s) equivalent group.

[7] Alternatively, we could have required the order to have valid order receipt time NBBO quotes at all three time intervals, but we chose to use all the data available at each interval. This results in a very slightly different number of observations for each interval.

when share-weighted. The share-weighted numbers find that the low-priced securities, which have many more shares traded in our sample, not surprisingly, enjoy a much tighter dollar quoted spread. The mean order size is 444 shares and, on average, 94% of ordered shares are filled.[8] A mean trade size of 321 shares compared to a mean of 418 shares filled at the order level, suggest a mean of 1.30 trades per order. 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.

Finally, we collect 453,256,063 trades reported to a Trade Reporting Facility (TRF) – exchange code D - in the NYSE's Trade and Quote (TAQ) database for May 2022 that can be matched to a valid execution-time NBBO. We use this additional group of trades to more thoroughly examine the effect of the SEC's decision to use the TAQ data to estimate the potential cost associated with the OCR. The BJZZ algorithm identifies 122,910,277 of these trades as retail (27.12%), and we are able to match 122,901,839 of these BJZZ-identified TAQ trades to valid mark out quotes 25ms, 100ms, and 300ms after trades are executed. We report TAQ TRF trade- and share-weighted statistics equivalent to the statistics reported for the proprietary retail order/trade data in Panels D and E, respectively, of Table 1 (given that we are working with TAQ data, order-weighted statistics are not obtainable). The selected descriptive statistics are quite similar to the equivalent statistics from the wholesaler(s) data. The wholesaler(s) appear to have more trades from higher-priced securities, i.e., the mean and median trade-weighted prices are higher for the wholesaler(s) than for TAQ, but the share-weighted statistics are quite similar.

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

[8] 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.

for marketable orders (marketable trades).[9] 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:

- *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, because 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) marketable retail **trades** using the BJZZ 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 0.99. As noted previously, BJZZ argue that the sub-penny increment of trade prices is associated with the likelihood that the trade originates from a retail investor and use it to assign the order side (buy or sell) associated with a given trade.

[9] The SEC indicates that auctions will take between 100 and 300ms. We added the 25ms time interval to illustrate just how quickly many quotes move after order arrival/trade execution.

Trades on the full penny (sub-penny increment of zero) and trades with prices having a sub-penny increment between .4 and .6 are not classified as retail trades by the BJZZ algorithm – they argue that these trades are less likely to be from retail investors in the current market structure. We diverge from the SEC's analysis initially in that we focus entirely on the data-providing wholesaler(s) trades as we know that they are all considered retail.[10] 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 0.4 to 0.6 range. For these trades, we follow BJZZ and infer the order side from the sub-penny increment.[11] 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 judged to be not retail by BJZZ, 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. Because all of these trades are presumed to be from retail investors, comparing the BJZZ-identified sample of retail trades to the BJZZ-unidentified sample of retail trades provides insight into whether the BJZZ algorithm might be biased for this particular application.

Finally, we use the BJZZ algorithm to identify retail trades in the NYSE's TAQ database in May 2022, which is publicly available. We refer to these trades as BJZZ-identified TAQ TRF trades. In contrast to the Commission, who analyzes BJZZ-identified TAQ TRF trades in a sample of stocks, we study trades in all securities that are reported to a TRF. We follow BJZZ and infer the order side from the sub-penny increment for this sample of trades. Unlike the midquote and far touch measures of slippage, trade price slippage is a function of the trade price, which is also used to type the trade as originating from a buy or sell order. Thus, trades that are mis-sided by BJZZ are likely to show a large benefit from a failed auction.[12]

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[10] 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.

[11] 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.

[12] The bulk of the outliers for the trade price slippage measure using TAQ trades appear to be trades that are mis-sided by BJZZ. For a hypothetical example consider a very large trade that occurs many dollars above the trade-time NBO but occurs at a price with a sub-penny increment between zero and .4. This is typed as a sell order by BJZZ based on

To avoid implementing one or more screens to eliminate the trades with abnormal prices, we do not compute the trade price slippage measure for the BJZZ-identified TAQ TRF trades. We do not encounter this problem when using retail trades from the wholesaler(s) because we know the actual trade side.

In summary, our analyses have four samples (all orders, BJZZ-identified retail trades, BJZZ-unidentified retail trades, and BJZZ-identified TAQ TRF trades), three time intervals for NBBO quote slippage (25 milliseconds, 100 milliseconds, and 300 milliseconds) and as many as three measures of quote slippage (Midquote, Far Touch, and Trade Price). As we do not compute Trade Price slippage for TAQ TRF trades, we have a total of 35 analyses.

III. Analysis of all retail orders, all retail trades, and all TAQ TRF trades identified as retail.

In this portion of the analysis, we assume that market participants incorporate the Commission's cost-benefit analysis as accurate and, thusly, all of the wholesaler(s) shares are routed to auctions, i.e., the wholesaler community does not take advantage of any exemptions. 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 four samples (all marketable orders, BJZZ-identified retail trades, BJZZ-unidentified retail trades, and BJZZ-identified TAQ TRF 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 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.]

the sub-penny interval suggesting a substantial gain to the investor but is most likely a buy order (see Barber et al. (2022) for a discussion of using Lee and Ready (1991) as an alternative to sub-penny increments for siding trades).

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 the wholesaler(s) marketable orders for 13.46% of the shares in the 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 far touch prevailing 25 milliseconds after orders are received by wholesaler(s) reveals that when the price improvement provided by wholesalers is factored in, 9.71% 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 (potentially) failed auctions for orders that experience adverse quote fades. The average potential cost per share 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 auctions (100-300ms). Finally, column 4 presents the potential total 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). Thus, we find that the Commission decision to use mid-quote price slippage as the metric with which to measure potential failed auction cost results in the lowest total cost of the three metrics we examine.

Panels B, C and D 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 (i.e., retail trades in our proprietary dataset that **are not** classified as retail trades by the BJZZ algorithm), Panel C presents these statistics for BJZZ-identified retail trades (i.e., retail trades in our proprietary dataset that **are** classified as retail trades

by the BJZZ algorithm), and Panel D presents these statistics for BJZZ-identified TAQ TRF trades (i.e.., trades in the publicly available TAQ database that are reported to a TRF and identified as retail trades by the BJZZ algorithm) in May 2022.

An inspection of Panels A through D 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. For each of the three measures of fade costs, the percentage of shares impacted by adverse quote moves is larger when order receipt times are used in the quote analysis than when BJZZ-identified retail trades, BJZZ-unidentified retail trades, or BJZZ-identified TAQ TRF trades which benchmark to trade times. Thus, using trade time quote benchmarks (as the Commission did) systematically underestimates the likelihood of adverse quote movement for known retail trades even at a very short 25ms. Furthermore, all of our estimates of the likelihood that shares are affected by adverse quote moves are much higher than the Commission's estimate of 1.8% of trades. 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 retail trades. The average per share cost of fades computed using all marketable orders and the average per share cost of fades computed using BJZZ-identified TAQ TRF trades each lie between the BJZZ-unidentified retail trades and the BJZZ-identified retail trades average per share estimates. Thus, of datasets we consider, the sample of BJZZ-identified retail trades (which was used in the Commission's fade cost analysis) produces the lowest per share fade cost estimates.

The percentage of shares in BJZZ-identified retail trades for which the 25 millisecond mark-out midquote moves against the retail investor is 9.50% while the percentage of shares in BJZZ-identified TAQ TRF trades with adverse midquote moves is 6.55%. The difference in the percentage of shares with adverse movements in the far touch computed using the 25 millisecond mark-out far touch quotes is smaller: 6.32% of shares in BJZZ-identified retail trades versus 4.29% in BJZZ-identified TAQ TRF trades. Regardless, the percentage of shares for which the mid-quote or far touch move against the investor in the 25 milliseconds following the receipt of marketable retail orders is more than twice the percentage computed

using BJZZ-identified TAQ TRF trades (i.e., the method used by the SEC in their analysis of potential costs). Furthermore, our mid-quote slippage frequency for shares at 25ms exceeds the Commission's slippage frequency for trades at 300ms.

Panel E of Table 2 presents the expected per share potential costs of failed auctions. 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.[13] So, to obtain the expected per share potential costs of failed auctions for our sample of marketable orders estimated using the Midquote Slippage measure of fade costs, we multiply 13.46% by \$0.0112, 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 the considerably longer 300ms delay. This estimate is also more than (almost) twice as high as the estimate of expected per share fade costs for BJZZ-identified TAQ TRF (retail) trades computed using the Midpoint Slippage measure of fade costs \$0.0007 (\$0.0008) in the last (second to last) column of Panel E of Table 2.

When the far touch is used to compute potential fade costs relative to order receipt time, 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 in the current market structure 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, 4 and 5 of Panel E reveal that per share expected fade costs computed using Midquote and Far Touch Slippage are highest for orders and are lowest for BJZZ-identified TAQ TRF trades. Indeed, the difference in expected fade costs for orders and for BJZZ-identified TAQ TRF trades is \$0.0008 per share for the Midquote Slippage measure and is \$0.0009 per

[13] We believe that the SEC multiplied the percent of trades 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. Likewise, larger orders/trades are likely associated with a larger per share cost than smaller orders/trades.

share for the Far Touch Slippage measure (but similar to the expected fade cost associated with BJZZ-identified retail trades).

Panel F of Table 2 contains annualized estimates of fade costs for the three different measures and the four different data sets. To compute the annualized estimates, we start with the consolidated volume of 798.58 billion shares traded in the first quarter of 2022. Next, using wholesaler Rule 605 reports for 1Q2022, 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 1Q2022 (which equals 798.58 billion shares x 0.1741) to arrive at an estimate of total fade costs in 1Q2022. Finally, we multiply this measure by 4 to arrive at an annualized estimate of downside fade costs.[14]

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 more than (almost) twice as high as the comparable estimate computed using BJZZ-identified TAQ TRF trades (BJZZ-identified retail 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. Using BJZZ-identified TAQ TRF trades rather than BJZZ-identified retail trades amplifies this difference. Finally, for our sample, the BJZZ 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 retail trades).[15] Together, the results presented in Table 2 suggest that the use or orders rather than trades and the

[14] We believe that this annualization approach (multiplying 1Q2022 times four) is consistent with the Commission's approach to computing annualized benefits.

[15] Note that the mean fade costs for the wholesaler(s) *orders* is not an average of the fade cost of the BJZZ-identified and the BJZZ-unidentified *trades*. The order analysis uses the order receipt time quote for a benchmark quote and the latter uses the trade time quote as a benchmark.

use of BJZZ-identified TAQ TRF trades rather than BJZZ-identified retail trades results in significantly lower estimates of annualized downside fade costs.[16]

[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 22.38% at 300 milliseconds. Possibly more consistent with the SEC's analysis, for our BJZZ-identified TAQ TRF trades (Panel D, column 2 of Tables 2, 3 and 4), the fade probability computed using NBBO midpoints rises from 6.55% of executed shares at 25 milliseconds, to 9.17% of executed shares at 100 milliseconds, and to 12.57% 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 retail trades than it is for both BJZZ-identified retail trades and BJZZ-identified TAQ TRF trades. Finally, for BJZZ-unidentified retail 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.

[16] It is difficult to unentangle the effect of biases in the BJZZ algorithm from the Commission's decision to look at a random sample of securities that is somewhat non-representative of the securities retail investors actually trade. The fact that the two BJZZ-identified samples report the lowest estimated costs suggests that biases in the BJZZ methodology are at least part of the reason for the difference. The Commission has not responded to requests to provide the list of symbols used in their analyses.

For 100 and 300 millisecond mark-out quotes, the fade probability computed using the Midpoint Slippage measure is higher for BJZZ-unidentified retail trades than it is for BJZZ-identified TAQ TRF 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.

For all of the mark-out periods 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 retail trades, BJZZ-unidentified retail trades, or BJZZ-identified TAQ TRF trades and execution-time quotes are used (see Panels A, B, C, and D of Tables 2, 3, and 4). 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, strongly 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 to 300 millisecond mark-out quotes increases the difference in the average per share cost of fades for orders and for BJZZ-identified TAQ TRF 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 TAQ TRF trades is $0.0006. When 100 millisecond mark-out quotes are used, this difference is $0.0037. 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 $0.0023 per share. 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.

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 TAQ TRF **trades** by $0.01 (the assumed per share adverse fade cost).[18] The SEC concludes that the expected per share 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 TAQ TRF trades, the expected per share fade costs measured using Midquote Slippage are 1.52 (25 millisecond mark-out quotes) to 4.13 (300 millisecond mark-out quotes) times larger than the SEC's estimate.

Consistent with the Commission's analysis, our estimates of the expected costs of failed auctions obtained using the Midquote Slippage measure for BJZZ-identified retail trades and for BJZZ-identified TAQ TRF trades in Panel E of Tables 2 and 3 are below the lower bound of the SEC's estimated benefits of auctions of $0.0015 per share at the 25 and 100 millisecond intervals. This is not true, however, for estimates of per share Midquote Slippage costs obtained for actual retail orders, which range from $0.0015

[17] See page 290 of the SEC's auction rule proposal.
[18] We expect that larger orders/trades to be more likely to have price impact so that the percent of shares affected would exceed the percent of trades affected. However, this does not seem likely to completely explain the large difference in the Commission's likelihood estimates and our calculations.

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, if all shares the cooperating wholesaler(s) currently execute are put through the proposed auction, 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. Moreover, 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 could be lost if the auction proposal is adopted.[19]

In Table 4, which employs a 300 millisecond mark-out time consistent with the SEC's maximum auction length, each of the eleven 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 for orders, BJZZ-unidentified retail trades, and for BJZZ-identified retail trades. 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. Each of the annualized estimates computed using order-receipt-time quotes as the benchmark instead of trade-time quotes greatly exceed $2 billion (as do all three of the measures computed using BJZZ-unidentified retail trades).

IV. Analysis of retail orders for less than $200,000 and retail and TAQ TRF trades for less than $200,000.

In the proposed OCR, "exceptions are provided for orders with a market value of $200,000 or more and for orders with execution prices (including prices constrained by non-marketable limit prices) that are very favorable for individual investors (i.e., the midpoint of the best displayed round lot quotations or better). These exceptions would not be mandatory, however, which means that broker-dealers could choose whether or not to route orders with these characteristics to an auction." The $200,000 threshold is designed

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

to exempt orders that may be difficult to execute efficiently in qualified auctions at prices that generally would be at or within the NBBO. While these large orders are eligible for an exception, they still would meet the definition of a "segmented order" and could be routed for execution in a qualified auction if the broker-dealer handling the order determines that such routing would promote best execution of the segmented order or if they took a conservative view of the OCR rule. Thus, the cost estimates in the prior section should be interpreted as consistent with the wholesaler(s) sending ALL marketable order flow to a qualified auction. In estimating auction benefits, the Commission addressed the fact that the large orders might not be submitted to an auction. In this section, we estimate potential auction costs after eliminating orders/trades for $200,000 notional value and greater from our sample.[20]

In Tables 5, 6, and 7, we redo the analyses presented in Tables 2, 3, and 4, respectively for each of the three mark-out times (25ms, 100ms, and 300ms) eliminating orders/trades with a notional value exceeding $200,000.[21] In the analyses of BJZZ-unidentified retail trades and BJZZ-identified retail trades, we report results using the notional size limit on individual trades (Trade Screen) consistent with the SEC and eliminating all trades associated with a large order (Order Screen). The latter eliminates more trades than the former.

[Insert Tables 5, 6 and 7 about here.]

Not surprisingly, the effect of eliminating large orders decreases both the percentage of shares potentially disadvantaged by failed auctions and the average per share cost of quote slippage. Compare, for

[20] As noted in the March 2023 draft of our comment letter, we were aware that our analysis was incomplete as we did not have time within the original comment period to compare the results obtained using actual marketable retail orders obtained from one or more wholesalers to results obtained using BJZZ-inferred TAQ TRF retail trades. As can be seen, we have incorporated this analysis into the current version of our comment letter. In the weeks after we submitted our comment letter, we became aware of the fact that we did not separately examine fade costs for retail orders and retail trades for no more than $200,000 worth of stock. From what we can tell, the Commission did not eliminate trades occurring at the NBBO midpoint from their analysis of potential auction benefits so we do not eliminate those trades from our analysis of potential auction costs.

[21] Because the Commission chose to use TAQ to analyze potential auction costs, they cannot eliminate large orders only large trades. In this section, when estimating the potential fade costs associated with forcing orders into auctions,, we eliminate all trades from large orders This eliminates considerably more shares than eliminating simply the trades for $200,000 notional or more. Said differently, the set of BJZZ-inferred TAQ TRF retail trades will continue to have trades generated by orders seeking to trade $200,000 or more worth of stock even after individual trades for more than $200,000 worth of stock are eliminated.

example, Panel A of Table 5 with Panel A of Table 2. The fraction of shares potentially affected by failed auctions with the large order filter in place is 93-96.5% as large as the fraction of shares affected for the unfiltered sample. The mean cost per share of disadvantaged shares is slightly more affected by the large order filter, dropping to 85-87% of the unfiltered sample. Thus, the large orders are associated with both more frequent fades and larger dollar quote fades. This is true for each of the mark out intervals (comparing Panel A in Table 6 with Panel A in Table 3 and comparing Panel A in Table 7 with Panel A in Table 4).

The large **trade** screen has little effect on the frequency of adverse moves for either BJZZ-identified retail trades or BJZZ-unidentified retail trades. Likewise, the trade screen has little effect on the BJZZ-unidentified retail trades mean cost per share. However, the trade screen does affect the BJZZ-identified retail trades proportionally more both on frequency of potential harm and mean dollar harm. Likewise, the BJZZ-identified TAQ TRF trades are affected at the longer mark out intervals for both frequency of potential harm and mean dollar amount of harm. **Thus, it appears that the Commission's use of BJZZ to identify retail trades produces greater decreases due to the large trade screen than what would have occurred using all retail orders.**

As expected, the large **order** screen has a greater dampening effect on both frequency of adverse quote moves and mean cost per share associated with those quote fades. The large order screen reduces the frequency of adverse quote moves to 83-89% of the unfiltered sample's frequency and reduces the mean cost per share to 80-86% of the unfiltered sample for the BJZZ-unidentified retail trades. For the BJZZ-identified retail trade sample, the large order screen has a smaller effect on the frequency of adverse quote moves (90-94.5% of the unfiltered sample's frequency) than the BJZZ-unidentified trade sample and a similar effect on the mean dollar adverse quote move cost (82-84% of the unfiltered sample's cost) as the BJZZ-unidentified trade sample. The effect of the large trade screen for the BJZZ-identified TAQ TRF trade sample lies between the BJZZ-unidentified and the BJZZ-identified retail trade samples.

As before, we take the product of the observed frequency of adverse quote movements and the mean dollar cost associated with those adverse quote movements to compute the potential expected cost per share imposed by the proposed OCR. Multiplying this expected cost by the estimated number of shares

executed by wholesalers in 2022 provides the overall estimated cost associated with implementing the proposed rule. Comparing the resulting cost estimate to the original analysis (assuming that all wholesaler shares would be routed to auctions) for the large order screen reduces the annualized cost estimate to between two-thirds and three-fourths of the unfiltered amount depending on the approach taken to measure costs (mid-quote move, far touch move, trade price versus far touch move). For the order size constrained BJZZ-unidentified (BJZZ-identified) retail trades, the annualized cost is about three-fourths (between 73% and 84%) of the unconstrained overall cost estimate. **In absolute terms, using the 100ms mark out quotes, the order size constrained order-based cost estimate still exceeds the Commission's lower bound benefit estimate for the far touch and trade price cost measurement and, at 300ms, approaches the Commission's upper bound using the trade price cost measurement. At 100ms, the BJZZ-unidentified retail trades large order constrained sample cost estimate exceeds the Commission's lower bound benefit estimate for the trade price cost measurement and at 300ms, all three cost measurements exceed the Commission's lower bound benefit estimate and the trade price cost estimate is nearly as large as the Commission's upper bound benefit estimate. Again, the BJZZ-identified retail and TAQ TRF samples have the lowest cost estimates of the samples we examine. However, the trade price measurement still produces a cost estimate equal to the Commission's lower bound for the BJZZ-identified retail trade sample at the 300ms interval. Thus, although assuming that all orders currently exceeding $200,000 are not put into the proposed auctions does reduce the estimated costs, it still seems likely that a cost approaching or exceeding the Commission's admittedly uncertain lower bound benefit are likely.**[22]

V. Alternative Marketable Limit Order Analysis

[22] We note that the SEC produces two cases for benefit estimates; initially assuming that all large orders (actually trades in their analysis) do not go to auctions and then assuming that half of them are sent to the proposed auction. We compute only the more conservative cost measure assuming that none of the large orders are sent to the auction. Obviously, it is clear that if even half of the estimated cost difference between the unconstrained and constrained samples' cost estimates is restored our calculations suggest that it is certainly possible for auction costs to exceed auction benefits.

In the analysis thus far, we treat market orders and marketable limit orders identically: we compute mid-point, far touch, and trade-price-far-touch slippage for **executed shares** in marketable limit orders. In this section, we consider an alternative approach to estimating the potential costs associated with failed auctions for both **executed and nonexecuted shares** in marketable limit orders that become non-marketable within 25ms, 100ms, and 300ms after they are received by the wholesaler(s). When computing this alternative measure of fade cost for marketable limit orders, we assume that the investor is motivated to trade and that the investor reaches across the quote to trade the entire order quantity at the far touch instead of at the limit price at the end of the failed auction. We compute the cost to that failed auction as the difference between the original limit price and the deferred far touch. Note that this cost will be assessed to both executed and unexecuted shares in marketable limit orders that experience adverse quote moves, not just the executed shares. Overall, there are 12,363,258 marketable limit orders in the dataset attempting to trade 6,666,707,688 shares. Table 8 summarizes our experience.

[Insert Table 8 about here.]

In Panel A of Table 8, we outline the number of marketable limit orders and associated shares in limit orders that become non-marketable in 25ms, 100ms, and 300ms. For all orders, as a percent of shares in all marketable limit orders, this is 6.75% at 25ms, 10.60% at 100ms, and 10.69% at 300ms. At the 300ms level, nearly a half million orders with 770 million shares potentially become non-marketable because of quote changes while in the proposed auction process. **The cost per share (again, computed by comparing the original limit price to the eventual far touch price) ranges from 2.27 cents to nearly three cents.** We annualize this cost per share by estimating the number of shares in a year that would be affected by becoming non-marketable during an auction that has the potential to fail. As before, we use the total volume of trading in 1Q2022 times four to estimate annual volume, multiply by the fraction of trading accounted for by wholesalers (.1741), multiply by the fraction of shares in orders that are marketable limit orders (.3721), multiply by the fraction of marketable limit orders that become non-marketable, and, finally, by the per share cost associated with marketable limit orders becoming non-marketable. For all orders, the annualized cost ranges from $317 million at 25ms to $648 million at 300ms. **In Panel C, we compare the**

new cost estimate (measured using both executed and unexecuted shares) with the previous cost estimate for these orders (measured using executed shares) and find, at the 100ms and 300ms level, the new approach adds over a quarter of a billion dollars per year at the time lags proposed in the OCR.

When focusing on the marketable limit orders with an original nominal amount (limit price times order quantity) less than $200,000, we find similar descriptive statistics. As can be seen in Panel B of Table 8, there are 12.2 million marketable limit orders with 5.7 billion shares out of a total of 40.7 million 'small' marketable limit orders and 17.8 billion shares. After 25ms, there are 222,552 marketable orders that become non-marketable representing almost 408 million shares. This climbs to 346,827 (482,561) orders representing more than 602 million (657 million) shares after 100ms (300ms). We calculate cost per share and total annualized cost as described in the prior paragraph. Starting with 1Q2022 total volume (798.58 billion shares) times the market share for wholesalers (.1741) times 4 quarters gives 178.43 billion shares for wholesalers. Marketable limit orders for less than $200,000 represent 32.09% of the data providing wholesaler(s) shares, which we take as representative of all wholesalers. Shares in small marketable limit orders that become non-marketable after 25ms, 100ms, and 300ms, are 7.16%, 10.57% and 11.52%, respectively, of all small marketable limit order shares. The cost per share (again, computed by comparing the original limit price to the eventual far touch price) ranges from $0.0222 to $0.0284. **For the shortest and longest proposed auction times, the cost estimate is from $0.535B to $0.584B, greater than 90% of the nominal size unconstrained figure. This represents an additional cost of nearly $300 million per year (see Panel D of Table 8).**

VI. 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

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")."

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 not necessarily 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 but observable to auction participants) 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 three 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), retail trades in our sample of marketable retail orders that would not be identified as retail trades by the BJZZ algorithm, and trades in the publicly available TAQ database that are 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) while the BJZZ-identified TAQ TRF trades have both Type I and Type II errors.

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 an assumed $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.

The primary results obtained when analyzing **all** orders and trades regardless of size 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 which the SEC computed using BJZZ-identified TAQ TRF retail trades in 600 randomly selected NMS securities and exchange traded funds of 1.8% at 25 milliseconds, to 2.8% at 100 milliseconds, and to 4.6% at 300 milliseconds.
- 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 a time interval that is one-quarter of the duration of the shortest proposed auction.
- 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 and 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.

In addition to examining all orders and trades, we adjust our analysis to examine the impact that the Commission's proposed exemption for orders seeking to trade more than $200,000 has on potential fade cost estimates. When using **trades** to estimate fade costs – as the Commission did, we follow the Commission and examine all **trades** for less than $200,000. Because larger orders are more likely to execute in multiple trades (in our sample, large orders generate an average of 6.8 trades), this constraint does not eliminate all trades that are part of orders seeking to trade $200,000 or more. When using orders to estimate fade costs, we are able to impose the constraint precisely and examine orders for less than $200,000. Not surprisingly, we find that excluding all retail orders currently exceeding $200,000 somewhat reduces estimated fade costs. **However, our analysis suggests that even when larger retail orders are excluded, the potential costs associated with failed auctions are likely to exceed the Commission's admittedly uncertain lower bound estimate of the benefits of order by order auctions.**

The primary results obtained when analyzing orders or trades for less than $200,000 are as follows:

- The fraction of shares potentially affected by failed auctions with the large **order** filter in place is 93-96.5% as large as the fraction of shared affected for the unfiltered sample and the average cost per share of disadvantaged shares is 85-87% of the unfiltered sample. Thus, the large orders are associated with the larger dollar quote fade.
- The large **trade** screen has little effect on the frequency of adverse moves for either BJZZ-identified retail trades or BJZZ-unidentified retail trades. The trade screen does affect the BJZZ-identified retail trades and the BJZZ-identified TAQ TRF trades proportionally more both on frequency of potential harm and mean dollar harm. This suggests the Commission's use of BJZZ to identify retail trades

produces greater decreases due to the large trade screen than what would have occurred using all retail orders.

- The annualized estimate of fade costs computed using small retail orders and either the Far Touch Slippage measure or the Midquote Slippage measure equal or exceed the Commission's lower bound estimate of the benefits of the proposed OCR when either 100 millisecond mark-out quotes or 300 millisecond mark-out quotes are used to estimate potential fade costs.

To summarize, we are puzzled by the fact that the SEC decided to utilize an inferior dataset to examine the potential cost of failed auctions when they possess a superior set of data (the CAT data) which they used to examine the potential benefits. 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.

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Table 1. Descriptive statistics for marketable orders routed to one or more wholesalers in May 2022. Order receipt time (ORT) National Best Bid (NBB) and National Best Offer (NBO) quoted prices, trade price, order size and executed shares. Price statistics are computed with observations for which we have at least one trade on the order-weighted statistics and trades for which we have ORT quotes on the trade-weighted and share-weighted statistics.

Panel A. Order-weighted statistics for proprietary data – 40,838,852 orders, 40,774,195 orders with at least one trade price

Variable	Mean	Min.	25th Pct.	Median	75th Pct.	Max.
ORT NBB price	$142.44	$0.0003	$18.28	$52.63	$143.23	$4,668.15
ORT NBO price	$142.57	$0.0004	$18.31	$52.67	$143.33	$4,686.47
Average trade price	$142.51	$0.0003	$18.29	$52.65	$143.28	$4,668.15
Order size (shrs.)	444	1	4	26	173	3,413,000
Executed size (shrs.)	418	0	4	26	169	2,081,000

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

Variable	Mean	Minimum	25th Pct.	Median	75th Pct.	Maximum
Trade time NBB price	$124.00	$0.0062	$12.80	$45.13	$120.38	$4,668.16
Trade time NBO price	$124.11	$0.0067	$12.82	$45.17	$120.48	$4,686.47
Trade price	$124.06	$0.0003	$12.82	$45.15	$120.43	$4,681.47
Executed size (shares)	321	1	5	50	150	500,000

Panel C. Share-weighted statistics for proprietary data (16,969,48,691 shares).

Variable	Mean	Minimum	25th Pct.	Median	75th Pct.	Maximum
Trade time NBB price	$38.17	$0.0062	$1.79	$11.19	$38.31	$4,668.16
Trade time NBO price	$38.19	$0.0067	$1.78	$11.18	$38.30	$4,686.47
Trade price	$38.18	$0.0003	$1.79	$11.20	$38.31	$4,681.47

Panel D. Trade-weighted statistics for BJZZ-identified TAQ TRF retail trades (122,901,839 trades).

Variable	Mean	Minimum	25th Pct.	Median	75th Pct.	Maximum
Trade time NBB price	$112.04	$0.0003	$13.59	$42.97	$105.84	$4,677.19
Trade time NBO price	$112.15	$0.0004	$13.61	$43.00	$105.94	$4,696.00
Trade Price	$131.68	$0.0001	$13.50	$42.98	$105.89	$4,677.19
Executed Size (shares)	310	1	5	44	100	20,000,000

Panel E. Share-weighted statistics for BJZZ-identified TAQ TRF retail trades (38,101,971,838 shares).

Variable	Mean	Minimum	25th Pct.	Median	75th Pct.	Maximum
Trade Time NBB	$38.80	$0.0003	$1.45	$11.54	$40.37	$4677.19
Trade Time NBO	$38.89	$0.0004	$1.47	$11.56	$40.50	$4696.00
Trade price	$38.92	$0.0001	$1.46	$11.46	$40.44	$4,677.19

Table 2. Adverse fade costs for failed auctions estimated using 25 millisecond mark-out quotes and all orders or trades independent of size.

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 start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 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. Because of outliers in the TAQ data, we do not present the Trade Price Slippage measure for the BJZZ-identified TAQ trades. 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	9.71%	$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	$13,352,312
Far Touch Slippage	6.99%	$0.0184	$14,021,693
Trade Price Slippage	7.98%	$0.0357	$31,031,691

Panel C. 16,629,640 **BJZZ-identified retail trades** in May 2022. 31.4% of wholesaler trades in May 2022 are identified 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	$4,792,801
Far Touch Slippage	6.32%	$0.0127	$4,904,949
Trade Price Slippage	7.38%	$0.0190	$8,598,620

Table 2 (continued).

Panel D. 122,901,839 **BJZZ-identified TAQ TRF trades** in May 2022.

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	6.55%	$0.0106	$26,396,159
Far Touch Slippage	4.29%	$0.0165	$26,948,861

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ 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	Executed shares in orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0015	$0.0012	$0.0008	$0.0007
Far Touch Slippage	$0.0016	$0.0013	$0.0008	$0.0007
Trade Price Slippage	$0.0019	$0.0029	$0.0014	n.c.

Panel F. 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 in 1Q2022. The expected cost is computed by multiplying the probability that a share has an adverse mark-out quote times the unrounded 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	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.834 B	$0.667 B	$0.433 B	$0.386 B
Far Touch Slippage	$0.890 B	$0.723 B	$0.446 B	$0.394 B
Trade Price Slippage	$1.056 B	$1.613 B	$0.779 B	n.c.

n.c. Not computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers created when the BJZZ methodology almost certainly incorrectly sides a given trade.

Table 3. Adverse fade costs for failed auctions estimated using 100 millisecond mark-out quotes and all orders or trades independent of size.

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 start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 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	$52,744,953
Far Touch Slippage	16.83%	$0.0200	$57,236,600
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	$20,428,142
Far Touch Slippage	9.89%	$0.0201	$21,646,273
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 identified 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	$7,243,010
Far Touch Slippage	8.58%	$0.0145	$7,601,849
Trade Price Slippage	9.80%	$0.0194	$11,655,048

Table 3 (continued).

Panel D. 122,901,839 **BJZZ-identified TAQ TRF trades** in May 2022.

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	9.17%	$0.0124	$43,356,198
Far Touch Slippage	6.66%	$0.0183	$46,378,533

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ trades with adverse 100 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.

100 millisecond fade cost measure	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0031	$0.0019	$0.0012	$0.0011
Far Touch Slippage	$0.0034	$0.0020	$0.0012	$0.0012
Trade Price Slippage	$0.0033	$0.0038	$0.0019	n.c.

Panel F. 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 in 1Q2022. The expected cost is computed by multiplying the probability that a share has an adverse mark-out quote times the unrounded 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	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$1.724 B	$1.057 B	$0.660 B	$0.612 B
Far Touch Slippage	$1.891 B	$1.112 B	$0.692 B	$0.667 B
Trade Price Slippage	$1.835 B	$2.113 B	$1.057 B	n.c.

n.c. Not Computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers created when the BJZZ methodology almost certainly incorrectly sides a given trade.

Table 4. Adverse fade costs for failed auctions estimated using 300 millisecond mark-out quotes and all orders or trades independent of size.

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 start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 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	22.38%	$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	$30,424,729
Far Touch Slippage	13.31%	$0.0220	$31,832,760
Trade Price Slippage	15.09%	$0.0362	$59,349,673

Panel C. 16,629,640 **BJZZ-identified retail trades** in May 2022. 31.4% of wholesaler trades in May 2022 are identified 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	$11,172,876
Far Touch Slippage	11.33%	$0.0167	$11,579,691
Trade Price Slippage	12.88%	$0.0211	$16,609,772

Table 4 (continued).

Panel D. 122,901,839 **BJZZ-identified TAQ TRF trades** in May 2022.

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	12.57%	$0.0151	$72,288,264
Far Touch Slippage	9.59%	$0.0213	$77,919,450

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ trades with adverse 300 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.

300 millisecond fade cost measure	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$0.0039	$0.0028	$0.0018	$0.0019
Far Touch Slippage	$0.0042	$0.0029	$0.0019	$0.0020
Trade Price Slippage	$0.0046	$0.0055	$0.0027	n.c.

Panel F. 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 unrounded 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	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
Midquote Slippage	$2.169 B	$1.557 B	$1.056 B	$1.057 B
Far Touch Slippage	$2.336 B	$1.613 B	$1.057 B	$1.112 B
Trade Price Slippage	$2.558 B	$3.059 B	$1.508 B	n.c.

n.c. Not Computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers created when the BJZZ methodology almost certainly incorrectly sides a given trade.

Table 5. Adverse fade costs for failed auctions estimated using 25 millisecond mark-out quotes for orders/trades for less than $200,000.

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. 40,114,056 of these orders are for less than $200,000. We start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 122,071,792 of these trades are for $200,000 or less. We examine three measures of slippage: *Midquote Slippage*, *Far Touch Slippage*, and *Trade Price Slippage*. *Midquote Slippage (M.Q.)* 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 (F.T.)* 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 (T.P.)* 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. Because of outliers in the TAQ data, we do not present the Trade Price Slippage measure for the BJZZ-identified TAQ trades. Consistent with the SEC's fade analysis in its 'Order Competition Rule' proposal, we focus on the potential costs of failed auctions. In addition, we limit the potential cost analysis to orders with a notional value (= order quantity times order-receipt-time mid-quote) less than $200,000 for the order analysis and trades with a notional value (= trade size times trade price) less than $200,000 for the trade analysis. In the trade analyses, we report results from both the screen eliminating trades associated with orders exceeding $200,000 notional and, in parentheses, the screen eliminating just trades exceeding $200,000 notional. The latter is consistent with our understanding of the SEC's analysis.

Panel A. 40,114,056 **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***
M.Q. – Order Screen	12.50%	$ 0.0095	$16,996,000
F.T. – Order Screen	10.28%	$ 0.0123	$18,138,492
T.P. – Order Screen	9.37%	$ 0.0173	$23,243,453

Panel B. **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***
M.Q. – Order Screen	7.97%	$0.0107	$7,464,289
M.Q. – Trade Screen	9.06%	$0.0129	$11,206,191
F.T. – Order Screen	5.83%	$0.0152	$7,803,080
F.T. – Trade Screen	6.96%	$0.0178	$11,864,953
T.P. – Order Screen	6.78%	$0.0309	$18,393,437
T.P. – Trade Screen	7.85%	$0.0324	$24,360,590

Table 5 (continued).

Panel C. **BJZZ-identified retail trades** in May 2022. 31.4% of wholesaler trades in May 2022 are identified 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***
M.Q. – Order Screen	8.98%	$0.0067	$3,325,987
M.Q. – Trade Screen	9.24%	$0.0074	$3,882,454
F.T. – Order Screen	5.90%	$0.0105	$3,389,724
F.T. – Trade Screen	6.18%	$0.0115	$4,021,917
T.P. – Order Screen	6.93%	$0.0155	$5,916,983
T.P. – Trade Screen	7.26%	$0.0173	$7,101,822

Panel D. 122,071,792 **BJZZ-identified TAQ TRF trades** in May 2022.

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***
M.Q. – Trade Screen	6.37%	$0.0097	$20,255,611
F.T. – Trade Screen	4.29%	$0.0165	$20,755,486

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ 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	Executed shares in orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$0.0012	$0.0009	$0.0006	n.a.
M.Q. – Trade Screen		$0.0012	$0.0007	$0.0006
F.T. – Order Screen	$0.0013	$0.0009	$0.0006	n.a.
F.T. – Trade Screen		$0.0012	$0.0007	$0.0007
T.P. – Order Screen	$0.0016	$0.0021	$0.0011	n.a.
T.P. – Trade Screen		$0.0025	$0.0013	n.c.

Table 5 (continued).

Panel F. 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 unrounded 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	Orders for which mark-out NBBO ***moves against investor***	BJZZ-unidentified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified retail trades for which mark-out NBBO ***moves against investor***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$0.667 B	$0.473 B	$0.335 B	n.a.
M.Q. – Trade Screen		$0.690 B	$0.378 B	$0.334 B
F.T. – Order Screen	$0.723 B	$0.495 B	$0.345 B	n.a.
F.T. – Trade Screen		$0.684 B	$0.395 B	$0.389 B
T.P. – Order Screen	$0.890 B	$1.168 B	$0.612 B	n.a.
T.P. – Trade Screen		$1.390 B	$0.701 B	n.c.

n.a. Not applicable to TAQ trades.
n.c. Not Computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers created when the BJZZ methodology almost certainly incorrectly sides a given trade.

Table 6. Adverse fade costs for failed auctions estimated using 100 millisecond mark-out quotes for orders/trades for less than $200,000.

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. 40,114,056 of these orders are for less than $200,000. We start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 122,071,792 of these trades are for $200,000 or less. We examine three measures of slippage: *Midquote Slippage*, *Far Touch Slippage*, and *Trade Price Slippage*. *Midquote Slippage (M.Q.)* 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 (F.T.)* 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 (T.P.)* 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. In addition, we limit the potential cost analysis to orders with a notional value (= order quantity times order-receipt-time mid-quote) less than $200,000 for the order analysis and trades with a notional value (= trade size times trade price) less than $200,000 for the trade analysis. In the trade analyses, we report results from both the screen eliminating trades associated with orders exceeding $200,000 notional and, in parentheses, the screen eliminating just trades exceeding $200,000 notional. The latter is consistent with our understanding of the SEC's analysis.

Panel A. 40,114,056 **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***
M.Q. – Order Screen	17.13%	$0.0117	$28,789,380
F.T. – Order Screen	14.88%	$0.0150	$31,971,686
T.P. – Order Screen	14.98%	$0.0169	$36,133,758

Panel B. **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***
M.Q. – Order Screen	10.87%	$0.0122	$11,649,831
M.Q. – Trade Screen	12.00%	$0.0144	$16,557,989
F.T. – Order Screen	8.35%	$0.0166	$12,227,870
F.T. – Trade Screen	9.56%	$0.0193	$17,665,722
T.P. – Order Screen	9.57%	$0.0291	$24,505,029
T.P. – Trade Screen	10.73%	$0.0313	$32,183,944

Table 6 (continued).

Panel C. **BJZZ-identified retail trades** in May 2022. 31.4% of wholesaler trades in May 2022 are identified 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***
M.Q. – Order Screen	10.98%	$0.0082	$4,936,344
M.Q. – Trade Screen	11.28%	$0.0089	$5,647609
F.T. – Order Screen	7.79%	$0.0121	$5,165,825
F.T. – Trade Screen	8.13%	$0.0130	$5,983,286
T.P. – Order Screen	8.99%	$0.0159	$7,863,986
T.P. – Trade Screen	9.37%	$0.0176	$9,327,758

Panel D. 122,071,792 **BJZZ-identified TAQ TRF trades** in May 2022.

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***
M.Q. – Trade Screen	7.52%	$0.0112	$32,121,982
F.T. – Trade Screen	5.45%	$0.0165	$34,216,766

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ trades with adverse 100 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.

100 millisecond fade cost measure	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$0.0020	$0.0013	$0.0009	n.a.
M.Q. – Trade Screen		$0.0017	$0.0010	$0.0008
F.T. – Order Screen	$0.0022	$0.0014	$0.0009	n.a.
F.T. – Trade Screen		$0.0018	$0.0011	$0.0009
T.P. – Order Screen	$0.0025	$0.0028	$0.0014	n.a.
T.P. – Trade Screen		$0.0034	$0.0016	n.c.

Table 6 (continued).

Panel F. 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 unrounded 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	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$1.119 B	$0.740 B	$0.501 B	n.a.
M.Q. – Trade Screen		$0.962 B	$0.556 B	$0.445 B
F.T. – Order Screen	$1.242 B	$0.773B	$0.523 B	n.a.
F.T. – Trade Screen		$1.023 B	$0.584 B	$0.501 B
T.P. – Order Screen	$1.404 B	$1.557 B	$0.779 B	n.a.
T.P. – Trade Screen		$1.869 B	$0.912 B	n.c.

n.a. Not applicable to TAQ trades.
n.c. Not Computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers created when the BJZZ methodology almost certainly incorrectly sides a given trade.

Table 7. Adverse fade costs for failed auctions estimated using 300 millisecond mark-out quotes for orders/trades for $200,000 or less.

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. 40,114,056 of these orders are for less than $200,000.We start with 453,256,063 TAQ trades reported to a TRF in May 2022. The BJZZ algorithm identifies 122,910,277 of these trades as retail and 122,901,839 of these trades can be matched to valid execution time and mark-out NBBOs. 122,071,792 of these trades are for $200,000 or less. We examine three measures of slippage: *Midquote Slippage*, *Far Touch Slippage*, and *Trade Price Slippage*. *Midquote Slippage (M.Q.)* 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 (F.T.)* 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 (T.P.)* 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. In addition, we limit the potential cost analysis to orders with a notional value (= order quantity times order-receipt-time mid-quote) less than $200,000 for the order analysis and trades with a notional value (= trade size times trade price) less than $200,000 for the trade analysis. In the trade analyses, we report results from both the screen eliminating trades associated with orders exceeding $200,000 notional and, in parentheses, the screen eliminating just trades exceeding $200,000 notional. The latter is consistent with our understanding of the SEC's analysis.

Panel A. 40,114,056 **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***
M.Q. – Order Screen	20.15%	$0.0131	$37,848,313
F.T. – Order Screen	17.50%	$0.0165	$41,207,340
T.P. – Order Screen	17.85%	$0.0198	$50,629,322

Panel B. **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***
M.Q. – Order Screen	14.50%	$0.0142	$18,063,572
M.Q. – Trade Screen	15.57%	$0.0160	$23,910,642
F.T. – Order Screen	11.51%	$0.0185	$18,765,801
F.T. – Trade Screen	12.69%	$0.0207	$25,212,858
T.P. – Order Screen	13.20%	$0.0311	$36,100,521
T.P. – Trade Screen	14.32%	$0.0328	$45,025,484

Table 7 (continued).

Panel C. **BJZZ-identified retail trades** in May 2022. 31.4% of wholesaler trades in May 2022 are identified 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***
M.Q. – Order Screen	13.99%	$0.0099	$7,608,894
M.Q. – Trade Screen	14.31%	$0.0105	$8,483,012
F.T. – Order Screen	10.20%	$0.0141	$7,882,215
F.T. – Trade Screen	10.57%	$0.0149	$8,865,044
T.P. – Order Screen	11.73%	$0.0175	$11,253,748
T.P. – Trade Screen	12.14%	$0.0189	$12,961,064

Panel D. 122,071,792 **BJZZ-identified TAQ TRF trades** in May 2022.

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***
M.Q. – Trade Screen	10.32%	$0.0131	$51,461,796
F.T. – Trade Screen	7.82%	$0.0183	$54,419,956

Panel E. The expected per share fade costs for all orders, BJZZ-unidentified retail trades, BJZZ-identified retail trades, and BJZZ-identified TAQ trades with adverse 300 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.

300 millisecond fade cost measure	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$0.0026	$0.0021	$0.0014	n.a.
M.Q. – Trade Screen		$0.0025	$0.0015	$0.0014
F.T. – Order Screen	$0.0029	$0.0021	$0.0014	n.a.
F.T. – Trade Screen		$0.0026	$0.0026	$0.0014
T.P. – Order Screen	$0.0035	$0.0041	$0.0021	n.a.
T.P. – Trade Screen		$0.0047	$0.0023	n.c.

Table 7 (continued).

Panel F. 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 unrounded 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	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***	BJZZ-identified TAQ trades for which mark-out NBBO ***moves against investor***
M.Q. – Order Screen	$1.471 B	$1.146 B	$0.773 B	n.a.
M.Q. – Trade Screen		$1.385 B	$0.834 B	$0.779 B
F.T. – Order Screen	$1.601 B	$1.185 B	$0.801 B	n.a.
F.T. – Trade Screen		$1.457 B	$0.873 B	$0.779 B
T.P. – Order Screen	$1.968 B	$2.280 B	$1.274 B	n.a.
T.P. – Trade Screen		$2.608 B	$1.274 B	n.c.

n.a. Not applicable to TAQ trades.
n.c. Not Computed – We do not compute the Trade Price Slippage statistic for the TAQ trades because of outliers

Table 8. Analysis of Marketable Limit Orders

In this table, we examine marketable limit orders that become nonmarketable versus mark-out quotes of 25ms, 100ms, and 300ms. In Panels A and B, we attach a per share cost of that order equal to the absolute difference between the limit price and the far touch (NBO for buy orders and NBB for sell orders) of the mark-out quotes at each of the three time intervals. In Panels C and D, we present the difference in the opportunity cost assessed to all shares and the fade costs computed for executed shares in limit orders that become nonmarketable during the proposed auction.

Panel A. Opportunity cost of becoming nonmarketable during the auction: All marketable limit orders.

	25ms	100ms	300ms
Fraction orders becoming non-marketable	.0186	.0290	.0402
Number of non-marketable orders	228,554	347,099	494,578
Number of shares in non-marketable orders	446,533,328	701,523,694	770,178,421
Fraction shares becoming non-marketable	.0675	.1060	.1069
Cost per share	$0.0227	$0.0259	$0.0293
Annualized cost*	$0.317B	$0.568B	$0.648B

*Annualized cost = 1Q2022 shares x fraction from wholesalers x fraction marketable limit order x fraction that become unmarketable x cost per share x 4 quarters.

Panel B. Opportunity cost of becoming nonmarketable during the auction: Marketable limit orders for less than $200,000.

	25ms	100ms	300ms
Fraction orders becoming non-marketable	.0182	.0284	.0395
Number of non-marketable orders	222,552	346,827	482,561
Number of shares in non-marketable orders	408,644,439	602,765,009	657,311,753
Cost per share	$0.0222	$0.0250	$0.0284
Fraction shares becoming non-marketable	.0716	.1057	.1152
Annualized cost*	$0.284B	$0.535B	$0.584B

*Annualized cost = 1Q2022 shares x fraction from wholesalers x fraction marketable limit order x fraction that become unmarketable x cost per share x 4 quarters.

Panel C. Difference between the opportunity costs assessed to all shares and the fade costs computed for executed shares in limit orders that become nonmarketable during the proposed auction.

Mark-out quote lag length	Midpoint	Far Touch	Trade Price
25ms	$0.169B	$0.149B	$0.151B
100ms	$0.224B	$0.206B	$0.254B
300ms	$0.274B	$0.257B	$0.303B

Panel D. Difference between the opportunity costs assessed to all shares and the fade costs computed for executed shares in limit orders for less than $200,000 that become nonmarketable during the proposed auction.

Mark-out quote lag length	Midpoint	Far Touch	Trade Price
25ms	$0.152B	$0.126B	$0.127B
100ms	$0.286B	$0.268B	$0.282B
300ms	$0.296B	$0.274B	$0.286B