
MODERNIZING ODD LOT TRADING

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Traditional odd lot trades (i.e., trades involving fewer than 100 shares) now comprise over half of all equity trades on U.S. exchanges. Under Regulation National Market System, however, these trades are excluded from a market center’s trade execution statistics. In addition, while brokers are required to consider odd lot quotes as part of their duty of best execution, odd lot quotes are formally excluded from the calculation of the national best bid and offer. This Article, written for a symposium on the Future of Securities Regulation at Columbia Law School, examines whether these regulatory exclusions for odd lot trades and quotes increase trade execution costs for retail trades filled in non-exchange venues. Across more than 3 billion trades during 2020, odd lot trades filled in non-exchange venues received ten percent less price improvement than non-odd lot trades. In addition, using order book data from Nasdaq, examination of a sample of retail, non-exchange trades in two popular retail stocks—Amazon and GameStop—on January 27, 2021 reveals that thirty-one to forty-six percent of odd lot trades would have received better pricing had the venue filled the order at the Nasdaq odd lot quote. These results suggest that the differential treatment of odd lots and round lots in the regulation of U.S. market structure may impair the execution quality of marketable odd lot orders from retail traders.

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I. INTRODUCTION

Do trades for fewer than 100 shares in non-exchange venues receive worse pricing than trades involving 100 shares or more? And are these small-size orders filled at prices in non-exchange venues that are inferior to the best available stock exchange quote that could fill the order? As I show, the answer to both questions is yes, illustrating why U.S. equity markets have an odd lot problem.

Odd lots are trades and quotes for fewer than a “round lot,” which was traditionally defined to be 100 shares.¹ For years, the conventional wisdom was that odd lots primarily reflected small retail trades.² As a result, they were generally considered to be irrelevant for purposes of evaluating market liquidity or prices and were excluded from the consolidated trade and quote system.³ Today, however, the growing

¹ See, e.g., RULEBOOK § 4703(b) (The Nasdaq Stock Mkt. 2021) (defining round lot and odd lot). As noted below, the Securities Exchange Commission has recently revised the definition of a round lot (and, as a consequence, an odd lot) to be less than 100 shares for certain high-priced securities. See *infra* note 29 and accompanying text. The data used in this Article precede the effective date of this reform; therefore, this Article refers to any quote or trade for fewer than 100 shares as an “odd lot” quote or trade.

² Maureen O’Hara, Chen Yao & Mao Ye, *What’s Not There: Odd Lots and Market Data*, 69 J. FIN. 2199, 2199 (2014). As discussed below, those authors also emphasize that in the modern equities market, odd lots are no longer necessarily retail. See *id.* at 2200.

³ O’Hara et al., *supra* note 2, at 2199. Trade reports and updates to a trading venue’s best available quotes for U.S. equity securities listed on a national stock exchange are presently required to be disseminated in real time to two securities information processors (SIPs) for public distribution. Robert P. Bartlett III & Justin McCrary, *How Rigged Are Stock Markets? Evidence from Microsecond Timestamps*, 45 J. FIN. MKTS. 37, 38 (2019). The reporting system is governed by three U.S. national market plans, which are referred to in this Article as the “consolidated trade and quote system.” See *id.* at 41 (describing the institutional background). Since 2013, market centers have been required to report odd lot trades (but not odd lot quote updates) to the SIPs. See Order Approving Amendment No. 30 to the Joint Self-Regulatory Organization Plan Governing the Collection, Consolidation

number of heavily-traded, high-priced stocks,⁴ along with algorithmic trading strategies that slice and dice orders into smaller pieces to minimize price impact,⁵ have made small-size trades too common to ignore.

Figure 1 presents the percentage of daily odd lot trades reported to the consolidated tape from 2014 to 2020.⁶ That percentage has doubled since 2014 and was regularly over half of trades by the end of 2020.⁷ The dollar volume of odd lot trades quadrupled during the same period, from roughly five percent to nearly twenty percent.⁸

and Dissemination of Quotation and Transaction Information, 78 Fed. Reg. 66,788, 66,789 (Nov. 6, 2013); Order Approving the Eighteenth Substantive Amendment to the Second Restatement of the CTA Plan, 78 Fed. Reg. 66,789, 66,790 (Nov. 6, 2013). As discussed below, in December 2020 the Securities and Exchange Commission adopted a comprehensive reform of market data infrastructure, in part, aimed at addressing concerns with the omission of odd lot quotes from the consolidated trade and quote data. See *infra* notes 28–29 and accompanying text.

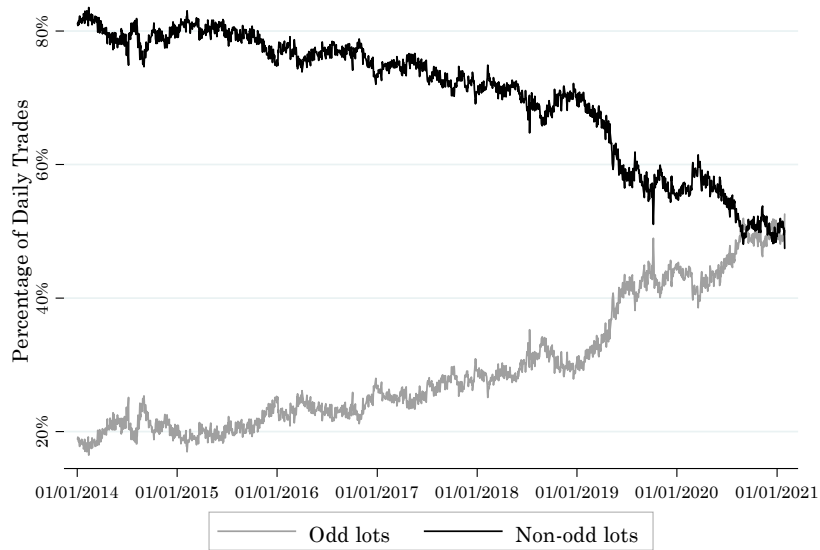
⁴ For instance, analysis of the NYSE Trade and Quote (TAQ) files, available through Wharton Research Data Services, WHARTON RSCH. DATA SERVS., <https://wrds-www.wharton.upenn.edu/pages/about/data-vendors/nyse-trade-and-quote-taq/> [<https://perma.cc/X6YC-NDF2>] (last visited May 24, 2021), reveals that in January 2014 there were approximately fifty exchange-traded equity securities having an average daily transaction price of \$200 or more. By January 2021, this number had grown over five-fold to nearly 290 securities. The TAQ data capture all trades and quotes reported in the consolidated trade and quote system. See *id.*

⁵ See O'Hara et al., *supra* note 2, at 2200.

⁶ Unless otherwise indicated, all trade and quote data used in this paper were obtained from the TAQ files, see *supra* note 4.

⁷ See also U.S. Exchanges Odd Lot Rate (%), U.S. SEC. & EXCH. COMM'N, https://www.sec.gov/marketstructure/datavis/ma_exchange_oddlotrate.html#YK1mvahKhPY [<https://perma.cc/G33P-9U9C>] (last visited May 25, 2021) (giving the most recent data); Alexander Osipovich, *Tiny 'Odd Lot' Trades Reach Record Share of U.S. Stock Market*, WALL ST. J. (on file with the Columbia Business Law Review), <https://www.wsj.com/articles/tiny-odd-lot-trades-reach-record-share-of-u-s-stock-market-11571745600> (last updated Oct. 23, 2019, 6:32 PM) (discussing the rise of odd lot trades as of 2019).

⁸ See also U.S. Exchanges Odd Lot Volume (%), U.S. SEC. & EXCH. COMM'N, https://www.sec.gov/marketstructure/datavis/ma_exchange_oddlotvolume.

Figure 1. Odd Lot Trading, 2014–20

Given the dramatic growth of odd lot trades, questions about deficient trade execution of marketable odd lot orders⁹

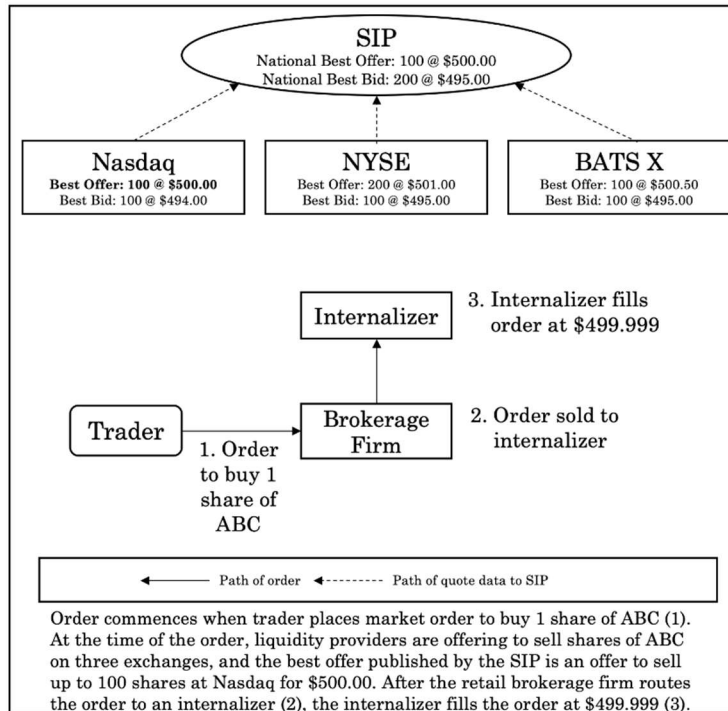
html#.YK1nj6hKhPY [<https://perma.cc/ZRZ2-T6CL>] (last visited May 25, 2021) (giving the most recent data); Phil Mackintosh, *Odd Facts About Odd Lots*, NASDAQ (Apr. 22, 2021, 10:23 AM), <https://www.nasdaq.com/articles/odd-facts-about-odd-lots-2021-04-22> [<https://perma.cc/Y5RG-XBAF>] (discussing trends in odd lot trades).

⁹ A marketable order is an order to buy or sell at the prevailing “market price,” and a broker-dealer “has a legal duty to seek best execution of” a customer’s marketable orders. *See id.* at 18,605 (citing Regulation NMS, 70 Fed. Reg. 37,496, 37,537 (June 29, 2005) (codified as amended in scattered parts of 17 C.F.R.)). This duty stems “from common law agency principles and fiduciary obligations,” *see id.* (citing Regulation NMS, 70 Fed. Reg. at 37,538), and the rules of the Financial Industry Regulatory Authority (FINRA)—the self-regulatory organization for broker-dealers—likewise require a broker-dealer to “use reasonable diligence to ascertain the best market for the subject security and buy or sell in such market so that the resultant price to the customer is as favorable as possible under prevailing market conditions.” FINRA R. 5310 (Fin. Indus. Regul. Auth. 2021). “In addition to the best price reasonably available, speed of execution and available liquidity, the [SEC] has articulated a non-exhaustive list of factors that may be relevant to [a broker’s] best execution analysis,” including “the size of the order . . . [.] the trading characteristics of the security involved,”

have become more important, especially for retail trades, where best execution is typically defined as receiving the best price available across different market centers.¹⁰ Consider the lifecycle of a typical marketable retail order, as depicted in Figure 2.

and the difficulty of achieving an execution in a particular market. See Market Data Infrastructure, 86 Fed. Reg. at 18,605 (citing *Kurz v. Fidelity Mgmt. & Rsch. Co.*, 556 F.3d 639, 640 (7th Cir. 2009)) (quoting Disclosure of Order Execution and Routing Practices, 65 Fed. Reg. 75,414, 75,418 (Dec. 1, 2000) (codified as amended at 17 C.F.R. pt. 242)).

¹⁰ See, e.g., Morris Mendelson & Junius W. Peake, *Intermediaries' or Investors': Whose Market Is it Anyway?*, 19 J. CORP. L. 443, 480 (1994). (“What most observers believe ‘best execution’ means—including every institutional and individual customer we have ever met—is that at the moment of the execution the net price paid is the lowest available or the net price received is the highest available.”); Francis J. Facciolo, *A Broker's Duty of Best Execution in the Nineteenth and Early Twentieth Centuries*, 26 PACE L. REV. 155, 156 (2005) (“[U]nformed small traders will care above all else about the price they receive or pay.”); Stavros Gadinis, *Market Structure for Institutional Investors: Comparing the U.S. and E.U. Regimes*, 3 VA. L. & BUS. REV. 311, 345 (2008) (“For retail investors trading in small increments, however, best execution will typically consist of obtaining the best possible price for their order.”) Indeed, several courts have held that it would be a violation of a broker-dealer's duty of best execution to fill a retail customer's marketable order at a price that is inferior to the price that is available in a different trading venue. See, e.g., *Newton v. Merrill, Lynch, Pierce, Fenner & Smith, Inc.*, 135 F.3d 266, 271–72 (1998) (en banc) (holding that, in an action for breach of duty of best execution against a retail brokerage firm that filled market orders at the NBBO, there was an issue of material fact as “to whether prices quoted on private on-line services like SelectNet and Instinet were reasonably available during the class period and whether those prices were more favorable than the NBBO when plaintiffs' orders were executed”); *Klein v. TD Ameritrade Holding Corp.*, 327 F.R.D. 283, 295 (2018) (holding that in a securities fraud action for breach of the duty of best execution, the economic loss that plaintiffs could claim “would be the difference between the price at which their trades were executed and the better price allegedly available from an alternative trading source” (internal quotation marks omitted) (quoting *Newton v. Merrill, Lynch, Pierce, Fenner & Smith, Inc.*, 259 F.3d 154 (3d Cir. 2001))), *rev'd and remanded on other grounds sub nom.* *Ford v. TD Ameritrade Holding Corp.*, 995 F.3d 616 (8th Cir. 2021).

Figure 2. Lifecycle of an Order

First, a retail trader places a marketable order to buy one share of ABC with a retail brokerage firm. Second, the broker sells the order to a wholesale market maker (known as an “internalizer”) who has agreed with the broker to fill retail market orders at a price that is at or better than the national best bid or offer (NBBO) displayed across all exchanges.¹¹ To determine the NBBO, the internalizer either subscribes to real-time proprietary data feeds offered by all sixteen U.S. stock exchanges or it relies on the (slightly slower) consolidated quotations published by two securities information processors (SIPs) responsible for administering

¹¹ See Robert P. Bartlett, III & Justin McCrary, *Dark Trading at the Midpoint: Does SEC Enforcement Policy Encourage Direct Feed Arbitrage?*, 4 J.L. FIN. & ACCT. 291, 300 & n.9 (2019).

the consolidated trade and quote system.¹² Trading venues are required to report and update their best available quotes to one of two SIPs; the SIP then redistributes those quotes to the public.¹³

In Figure 2, the SIP's best offer is from Nasdaq, to sell up to 100 shares of ABC for \$500. In the third step above, the internalizer fills the order for a single share of ABC at \$499.999. The trader therefore receives \$0.001 of price improvement from the internalizer versus the NBBO.¹⁴

¹² Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,599 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) ("In addition to the SIP data provided via the Equity Data Plans, most exchanges have developed . . . proprietary depth-of-book ('DOB') products that contain more extensive information that is not provided by the exclusive SIPs, such as complete order-by-order information, full depth of book information, auction information, and odd-lot quotation information."); *see also infra* note 22 (describing the use by Citadel, a wholesale market maker, of exchanges' proprietary data feeds to price retail trades).

¹³ *See supra* note 3. Trade and quote updates for NYSE-listed securities ("Tape A" securities) and securities listed on regional exchanges and their successors ("Tape B" securities) are reported to the SIP operated by the Securities Industry Automation Corporation ("SIAC"), a subsidiary of the NYSE; trade and quote updates for Nasdaq-listed securities ("Tape C" securities) are reported to the SIP operated by Nasdaq. *See Bartlett & McCrary, supra* note 3, at 41.

¹⁴ Having sold a single share of ABC to the retail trader, the internalizer would most likely cover the short position by filling any marketable sell orders received from the retail broker dealer at or better than \$495.00 (the prevailing national best bid), thus profiting from the bid-ask spread. Absent an inbound sell order, the internalizer could also cover the short position by posting an active order to buy on an exchange. *See Bartlett & McCrary, supra* note 11, at 300 & n.9. The agreement between the retail brokerage firm and the internalizer is typically referred to as a payment for order flow arrangement given that the internalizer will pay the retail brokerage firm for the market orders because of the profit potential of filling retail market orders in this fashion. *See Matt Levine, People Are Worried About Payment for Order Flow*, BLOOMBERG: OP. (Feb. 5, 2021, 12:09 PM), <https://www.bloomberg.com/opinion/articles/2021-02-05/robinhood-gamestop-saga-pressures-payment-for-order-flow> [<https://perma.cc/NAR3-NMMC>] (describing payment for order flow and internalization). In particular, retail orders are believed to be uninformed and more likely to reflect the random arrival of buy and sell trading interest than institutional order flow. As a result, filling marketable retail orders

The lifecycle depicted in Figure 2 can apply to an order that is either a round lot or an odd lot. However, the regulatory treatment of odd lot trading interest gives rise to two questions regarding this hypothetical trade's execution quality.

First, the trader might have received better pricing had the order been for more than 99 shares because trades for less than 100 shares are exempt from Rule 605 of Regulation National Market System (Reg NMS) (formerly SEC Rule 11Ac1-5).¹⁵ Rule 605 requires all market centers trading Reg NMS securities to provide monthly reports regarding the quality of their trade executions on a stock-by-stock basis, including the fraction of shares that received price improvement relative to the NBBO (as defined in Reg NMS) as well as "the share-weighted average amount per share that prices were improved."¹⁶ These reports provide potentially valuable information about execution quality, and therefore reduce the incentives of brokers and internalizers to profit at the expense of retail traders, but only for trades for 100 shares or more.¹⁷ In contrast, trades for less than 100 shares are

should permit an internalizer to capture the bid-ask spread. It is the proceeds from these payment for order flow arrangements that have allowed retail brokerage firms to provide zero-commission trading to their retail customers. *See id.* ("A few years back, Robinhood Markets Inc. had a crucial insight: Instead of charging a \$5 commission and passing along 80% of the wholesaler's discount to customers in the form of price improvement, it could charge *no* commission and pass along 20%, keeping the other 80% for itself.")

¹⁵ *See* 17 C.F.R. § 242.600(b)(11) (2020) (defining "Categorized by order size" for purposes of Rule 605 to be "dividing orders into separate categories for sizes from 100 to 499 shares, from 500 to 1999 shares, from 2000 to 4999 shares, and 5000 or greater shares"); *id.* § 242.605(a)(1) (establishing the obligation to report, categorizing in part "by order size").

¹⁶ *Id.* § 242.605(a)(ii)(B)–(C).

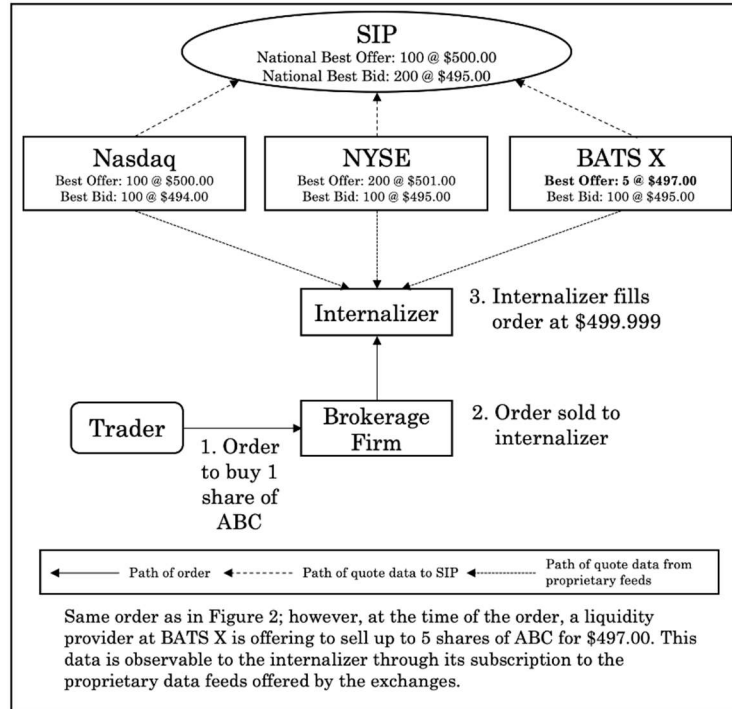
¹⁷ In the hypothetical trade in Figure 2, a trader interested in understanding the execution quality of orders submitted to the retail brokerage firm would first have to identify the internalizer(s) who acquired the brokerage firm's order flow by examining the broker's Rule 606 reports, *see* 17 C.F.R. § 242.606(a) (requiring every broker to provide quarterly disclosures of where its marketable orders have been routed), and then examine the Rule 605 reports for the relevant internalizer(s).

vulnerable to receiving worse pricing, because Rule 605 reports do not cover them.¹⁸

Second, there might be a better available offer than the SIP's best offer that the internalizer used to price the trade. In Figure 2, the SIP's best offer (from Nasdaq) actually was the best available offer across all exchanges. But suppose that is not the case and instead the exchanges' proprietary data feeds showed that an offer to sell five shares of ABC at \$497 was resting on BATS X, as reflected in Figure 3.

¹⁸ To be sure, a brokerage firm can actively monitor trade execution on behalf of its customers, and many brokerage firms do indeed publish summary trade execution statistics for market orders that are routed to wholesale market makers. E*Trade, for example, voluntarily discloses trade execution statistics on its website for order sizes between 100 and 999 shares. *Execution Quality*, E*TRADE, <https://us.etrade.com/trade/execution-quality> [<https://perma.cc/85HW-9QSL>] (last visited Mar. 19, 2021). Even these statistics, however, commonly exclude trades for fewer than 100 shares or lack the information required to examine the execution quality of smaller trades specifically. *See, e.g., id.* (excluding traditional odd lots); *Compare Online Brokers*, INTERACTIVE BROKERS, <https://investors.interactivebrokers.com/en/index.php?f=1340> [<https://perma.cc/NLU3-XVKH>] (last visited Mar. 19, 2020) (same). Robinhood and TD Ameritrade report trade execution statistics on their websites by aggregating all trades for fewer than 2,000 shares. *Our Execution Quality*, ROBINHOOD, <https://robinhood.com/us/en/about-us/our-execution-quality/> [<https://perma.cc/7MT5-DXLJ>] (last visited Mar. 19, 2021); *Order Execution Quality*, TD AMERITRADE, <https://www.tdameritrade.com/tools-and-platforms/order-execution.page> [<https://perma.cc/EED2-7CPZ>] (last visited Mar. 19, 2021). Schwab, however, provides average trade costs for orders involving fewer than 100 shares. *Retail Execution Quality Statistics (Q4 2020)*, CHARLES SCHWAB, <https://www.schwab.com/execution-quality/quality-statistics> [<https://perma.cc/CN6J-QDEX>] (last visited Mar. 19, 2021).

Figure 3. Lifecycle of an Order with Exchange Data Feeds



Under Reg NMS, the best bid or offer on an exchange is excluded from the official definition of “bid” or “offer”¹⁹ unless the aggregate size of all orders at the quoted price is equal to a round lot. As a result, while BATS X includes the five share quoted offer in its proprietary data feed, BATS X will not report this quote to the SIP because the quote does not meet Reg NMS’s definition of an “offer.” In other words, the best offer, at BATS X, is hidden from the SIP.

¹⁹ *Id.* § 242.600(b)(9) (defining “bid” or “offer” as “the bid price or the offer price communicated by a member of a national securities exchange or member of a national securities association to any broker or dealer, or to any customer, at which it is willing to buy or sell one or more round lots of an NMS security”).

Moreover, Rule 611's "trade-through" rule does not apply to odd lot quotes, and odd lots are excluded from the definition of the NBBO under Reg NMS.²⁰ As a result, even if the internalizer knows about this five-share offer because it subscribes to the BATS X proprietary data feed, the internalizer will not violate Rule 611's prohibition of trading "through" a superior priced quote, because this quote is excluded from the definition of the NBBO. To be sure, this hypothetical customer remains protected by a broker's duty of best execution.²¹ However, the practical challenge of monitoring and enforcing this duty (particularly for retail investors) raises a question of whether this duty is sufficient to ensure that an internalizer will consider odd lot quotes when filling and routing orders.²²

²⁰ 17 C.F.R. § 242.600(b)(43), (61) (2020) (defining "national best bid or offer," "protected bid," and "protected offer"); 17 C.F.R. § 242.611 (requiring each trading center to "establish, maintain, and enforce written policies and procedures that are reasonably designed to prevent trade-throughs on that trading center of protected quotations in NMS stocks" that do not fall within specific exceptions); *see also* Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,614 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249).

²¹ Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,614 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) ("[O]dd-lots are subject to best execution requirements, so investors have the assurance that their broker-dealers are required to seek the most favorable terms reasonably available under the circumstances for such orders despite the fact that the odd-lot quotes are not protected quotations pursuant to Rule 611." (citing Order Execution Obligations, 61 Fed. Reg. 48,290, 48,305 (Sept. 12, 1996) (codified as amended at 17 C.F.R. pt. 240))).

²² The possibility that an internalizer might trade-through odd lot quotes that it observes in exchanges' proprietary data feeds was highlighted in the SEC's 2017 enforcement action against Citadel Securities. *See generally* Citadel Sec. LLC, Securities Act Release No. 10,280, 2017 WL 129905 (Jan. 13, 2017). There, the SEC documented the use by Citadel of a "FastFill" protocol in which Citadel would automatically execute a retail market order at the price of the SIP NBBO when the best price from an exchange's direct feed was better than the best price disseminated by the SIP feed. *Id.* at *3. Notably, the enforcement action was based on a disclosure violation under section 17 of the Securities Act given that Citadel had disclosed to broker-dealer clients that a market order was an "[o]rder to buy (sell) at the best offer (bid) price currently available in the marketplace." *Id.* at *8 (alteration in original) (internal quotation marks

These considerations motivate the two empirical questions at the heart of this Article. First, I compare the rate and level of price improvement for odd lot trades relative to round lot trades. Second, I compare odd lot trades to odd lot quotes. Both comparisons show that odd lot trades are at a heightened risk of deficient trade execution.

To explore the first question, I examine all reported quotes and trades in the NYSE TAQ data²³ since 2014 for securities in the Dow Jones Industrial Average to calculate the rate and level of price improvement for each trade based on its reported size.²⁴ Price improvement for odd lot trades executed in non-exchange venues has improved markedly relative to round lots since odd lot trades first appeared in the consolidated tape in late 2013. Moreover, much of the increase in price improvement rates appears related to a voluntary program commenced in 2015 by several internalizers and brokerage firms to improve the disclosure of retail trade execution statistics.²⁵ However, overall levels of price improvement for odd lot trades in non-exchange venues have remained consistently lower than those for larger trades.

This conclusion is further supported by a regression discontinuity (RD) analysis of price improvement by trade size for all securities with 2020 daily trading volume of greater than \$5,000,000. Controlling for overall volume for different trade sizes, odd lot trades in non-exchange venues receive on average roughly ninety percent of the price improvement (measured in quoted half-spreads) provided to larger trades. Such systematically lower price improvement for odd lot trades in non-exchange venues is consistent with the above

omitted). Nothing in the resulting cease-and-desist order would therefore prohibit the practice provided its disclosure is made to a broker-dealer.

²³ See *supra* note 4.

²⁴ As discussed in *supra* note 3, market centers have been required to report odd lot trades (but not quote updates) to the consolidated trade and quote system since 2013; therefore, the sample period commences with the first full calendar year that odd lot trades are available in the TAQ data.

²⁵ See *infra* text accompanying notes 50–53.

discussion of the difficulty of monitoring the execution quality of odd lot trades relative to round lots.²⁶

Turning to the second question, I use top-of-book quotation data from Nasdaq's proprietary data feed for two popular retail securities on January 27, 2021—Amazon and GameStop—to examine the extent to which non-exchange odd lot trades could have received superior pricing had they been routed to Nasdaq or otherwise filled at odd lot prices displayed on Nasdaq.²⁷ Notably, by January 2021 the Securities and Exchange Commission (SEC) had completed a comprehensive reform of market data infrastructure (the “2020 Market Data Reform”) that, among other things, sought to address the possibility that odd lot quotes are traded through, meaning that a buy (sell) trade occurs at a price that is worse than the best available offer (bid) displayed on an exchange.²⁸ In particular, the reform creates a four-tier definition of a “round lot” based on the average closing price for a security during the preceding month that will reduce the number of unprotected odd lot quotations for higher-priced securities.²⁹

²⁶ See Christopher Nagy, *Enhanced Retail Execution Statistics Raise Best Ex Concerns*, TABB F. (July 14, 2015) (on file with the Columbia Business Law Review), <https://tabbforum.com/opinions/enhanced-retail-execution-statistics-raise-best-ex-concerns/>.

²⁷ Nasdaq order book data was obtained from the Limit Order Book Reconstruction System (LOBSTER). See *LOBSTER: High-Frequency, Easy-To-Use and Latest Limit Order Book Data for Your Research*, LOBSTER, <https://lobsterdata.com> [<https://perma.cc/SM5P-A8WS>] (last visited Mar. 15, 2021).

²⁸ See Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,601-18,615 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) (amending the “round lot” definition “[t]o better ensure the display and accessibility of significant liquidity for higher-priced stocks” and adding odd lot quotation data, as well as depth-of-book data, to the publicly disseminated “core data” to “allow some market participants to trade in a more informed, competitive, and efficient manner”).

²⁹ The reform creates a four-tier definition of a round lot based on the average closing price for a security during the preceding month: a round lot will be forty shares for a security with a price between \$250.01 and \$1,000, ten shares for a security priced between \$1,000.01 and \$10,000, and one share for a security priced above \$10,000. For all other securities, a round lot will remain 100 shares. See *Id.* at 18,612 tbl.1. Additionally, non-hidden

The critical point for purposes of the empirical analysis is that given the widely-followed two-year process of adopting the 2020 Market Data Reform, it was well known by January 2021 that odd lot quotes were available through exchanges' proprietary data feeds,³⁰ and commentary during the 2020 Market Data Reform highlighted that the largest internalizers rely on proprietary data feeds for routing and pricing trades.³¹ Likewise, the reform itself reaffirmed the SEC's position, long-held by FINRA, that brokers "must examine their procedures for seeking to obtain best execution in light of market and technology changes and modify those

orders that constitute odd lot quotes under this new definition must also be disseminated as publicly-available "core" data to the extent the quotes are priced at or more aggressively than the NBBO. *Id.* at 18,612–13.

³⁰ See *supra* note 12.

³¹ See, e.g., Market Data Infrastructure, 85 Fed. Reg. 16,726, 16,752 n.284 (proposed Mar. 24, 2020) (codified at 17 C.F.R. pts. 240, 242, 249) (summarizing a Citadel representative's statement: "proprietary feeds are required for best execution"); Letter from Douglas A. Cifu, Chief Exec. Officer, Virtu Fin. Inc., to Brent J. Fields, Sec'y, U.S. Sec. & Exch. Comm'n 4 (Oct. 23, 2018), <https://www.virtu.com/uploads/2019/02/2018.10.23-Virtu%E2%80%99s-Comment-Letter-Roundtable-on-Market-Data-and-Market-Access.pdf> [<https://perma.cc/8F82-UL6E>] ("Simply put, Virtu could not fulfill its obligations to its myriad of retail customers and institutional clients without full depth of book market data feeds and robust exchange connectivity features that the SIP feeds alone do not offer.") As of this writing, Citadel and Virtu Financial execute approximately forty-seven percent and twenty-five percent of retail orders, respectively. See *Equities and Options*, CITADEL SEC. (on file with the Columbia Business Law Review), <https://www.citadelsecurities.com/products/equities-and-options/#:~:text=Our%20automated%20equities%20platform%20trades,top%20wholesale%20market%20maker2> (last visited May 24, 2021) ("We execute approximately 47% of all U.S.-listed retail volume[.]"); *Client Market Making*, VIRTU FIN., <https://www.virtu.com/market-making/client-market-making/#:~:text=We%20handle%20~25%25%20of%20market,retail%20investors%20in%20the%20US> [<https://perma.cc/Q26B-7FJB>] ("We handle ~25% of market orders placed by retail investors in the US [measured by Rule 605 market share].") Virtu Financial additionally notes in its comment letter that "[t]he firms that handle the vast majority of orders and execute the vast majority of trades must purchase both SIP and proprietary data in order to meet their best execution obligations and to meaningfully compete." Letter from Douglas A. Cifu to Brent J. Fields, *supra*, at 4.

practices if necessary.”³² If non-exchange venues were using odd lot quotes to route and/or price trades, there should be relatively few observed trades that could have received better pricing at Nasdaq. This should be especially true for odd lot trades that could be routed to Nasdaq, where they could interact with odd lot quotes of comparable size.

However, as described below, a substantial number of non-exchange odd lot trades were priced at or just better than the conventional NBBO despite better pricing available at Nasdaq. Focusing on the subset of non-exchange trades likely to represent internalized retail trades,³³ I find that approximately thirty-one percent of odd lot trades in Amazon and forty-six percent of odd lot trades in GameStop would have received better pricing had the venue filled the order at the Nasdaq odd lot quote. Moreover, using an NBBO that included Nasdaq’s odd lot quotes also reveals substantially lower levels of price improvement for non-exchange odd lot trades in these securities. For example, aggregate price improvement for this sample of retail trades in GameStop was approximately \$238 based on the conventional “round lot” NBBO, but benchmarking off of an NBBO that includes odd lot quotes at Nasdaq reveals that these trades collectively

³² Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,605 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) (quoting Regulation NMS, 70 Fed. Reg. 37,496, 37,538 (June 29, 2005) (codified as amended in scattered parts of 17 C.F.R.)); *see also* FINRA, REGULATORY NOTICE 15-46, BEST EXECUTION: GUIDANCE ON BEST EXECUTION OBLIGATIONS IN EQUITY, OPTIONS AND FIXED INCOME MARKETS 13 n.12 (2015), https://www.finra.org/sites/default/files/notice_doc_file_ref/Notice_Regulatory_15-46.pdf [<https://perma.cc/V6GK-6W4U>] (“The exercise of reasonable diligence to ascertain the best market under prevailing market conditions can be affected by the market data, including specific data feeds used by a firm. For example, a firm that regularly accesses proprietary data feeds, in addition to the consolidated SIP feed, for its proprietary trading, would be expected to also be using these data feeds to determine the best market under prevailing market conditions when handling customer orders to meet its best execution obligations.”).

³³ Specifically, I exploit the fact that under Rule 612, sub-penny trades that provide very modest price improvement are very likely to represent retail trades filled by an internalizer. *See infra* note 77 and accompanying text.

received price *dis*-improvement of approximately \$206,000. That is, these trades would have received \$206,000 more if they had been priced at the “odd lot” NBBO. Even with a requirement that Nasdaq’s quotes have sufficient depth to cover the trade size, estimated price dis-improvement for these trades would be \$101,000.

Importantly, Nasdaq represents just one exchange that might have better odd lot quotes;³⁴ therefore, these numbers would likely show even greater differences between the Reg NMS NBBO and the odd lot NBBO were one to include in this analysis odd lot quotes from all exchanges. As such, these differences between the Reg NMS NBBO and the odd lot NBBO should be viewed as conservative estimates of the extent to which the NBBO would narrow were it to include all odd lot quotes.

Overall, these findings provide new evidence that the regulatory treatment of odd lot trades and quotes may impair the execution quality of marketable odd lot orders, particularly those executed by wholesale market makers. Moreover, these concerns remain despite the 2020 Market Data Reform. Once implemented, these reforms will leave intact the existing Rule 605 reporting requirements,³⁵ and although the new round lot definitions will reduce the number of odd lot quotes for high-priced securities, odd lot quotes that improve on the round-lot NBBO will remain a possibility. For these quotes, the 2020 Market Data Reform will require that they be included in the “core” data that is publicly available,³⁶ but the reforms continue to rely solely on a broker’s duty of

³⁴ As of the date of this Article, there are sixteen U.S. exchanges that trade equity securities. See *Latency Charts*, CONSOL. TAPE ASS’N, <https://www.ctapl.com/latency-charts> [<https://perma.cc/X9NM-CD9Z>] (last visited May 24, 2021).

³⁵ See Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,621 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) (“[W]hile the Commission has reviewed the comments about the need to modernize and update Rule 605, any changes to Rule 605 . . . are beyond the scope of the present rulemaking.”).

³⁶ Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,612–13 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249).

best execution to ensure that odd lot quotes are considered by brokers and internalizers when executing trades.³⁷

Given these findings, this Article therefore echoes those who have been advocating for a substantial update to Rule 605 to, among other things, require trade execution statistics for small-sized orders.³⁸ It additionally argues for eliminating the preference for round lot trades in Rule 611 once odd lot quotes and depth-of-book data appear in the consolidated trade and quote system, as is required by the 2020 Market Data Reform: to the extent Rule 611 protects orders against trade-throughs, it should protect all orders regardless of size. Lastly, reforming the regulatory treatment of odd lot trades also points to the desirability of modernizing trade execution metrics to utilize size-weighted price benchmarks, rather than simply the NBBO.

This Article proceeds as follows. Part II presents the empirical analysis of price improvement levels for trades of fewer than 100 shares relative to larger-sized trades. Part III examines whether non-exchange odd lot trades in Amazon and GameStop on January 27, 2021 could have received superior pricing based on Nasdaq's odd lot quotes. Part IV examines potential regulatory interventions to address the odd lot problem. Part V concludes.

II. PRICE IMPROVEMENT AND ODD LOT TRADING

This Part examines whether trades for fewer than 100 shares executed in non-exchange venues receive different levels of price improvement relative to trades involving 100 shares or more. For this purpose, price improvement is defined using the same definition of the NBBO that is utilized

³⁷ *Id.* at 18,614 (“[O]dd-lots are subject to best execution requirements, so investors have the assurance that their broker dealers are required to seek the most favorable terms reasonably available under the circumstances for such orders despite the fact that the odd-lot quotes are not protected quotations pursuant to Rule 611.”).

³⁸ See Virtu Fin., Inc., Comment Letter on Proposed Rule on Market Data Infrastructure 4 (May 26, 2020), <https://www.sec.gov/comments/s7-03-20/s70320-7229972-217068.pdf> [<https://perma.cc/WFH5-5HKS>].

for Rule 605.³⁹ That is, the NBBO is calculated based on each exchange's best bid and best offer disseminated on the consolidated trade and quote system.⁴⁰ Because the sample of trades precedes the 2020 Market Data Reform, the NBBO used for this purpose therefore excludes any bids or offers having a size of less than 100 shares.⁴¹

To conduct the analysis, I turn to the daily TAQ data, which includes all U.S. trades in exchange-listed securities that are printed to the consolidated tape as well as each update to a market center's best bid or offer published throughout the trading day.⁴² Given that odd lot trades were omitted from the consolidated tape prior to October 2013,⁴³ I begin by examining the time series variation in price improvement for odd lot trades since 2014, the first full year that they were included in the consolidated tape. Because of the extraordinarily large number of trade and quote updates during this time period, I confine the analysis to trades in the

³⁹ See 17 C.F.R. § 242.600(b)(29) (2020) ("Executed with price improvement means, for buy orders, execution at a price lower than the national best offer at the time of order receipt and, for sell orders, execution at a price higher than the national best bid at the time of order receipt." (emphasis deleted)).

⁴⁰ See *id.* § 242.600(b)(43) ("National best bid and national best offer means, with respect to quotations for an NMS security, the best bid and best offer for such security that are calculated and disseminated on a current and continuing basis by a plan processor pursuant to an effective national market system plan; provided, that in the event two or more market centers transmit to the plan processor pursuant to such plan identical bids or offers for an NMS security, the best bid or best offer (as the case may be) shall be determined by ranking all such identical bids or offers (as the case may be) first by size (giving the highest ranking to the bid or offer associated with the largest size), and then by time (giving the highest ranking to the bid or offer received first in time)." (emphasis deleted)).

⁴¹ See *supra* notes 19–20 and accompany text.

⁴² N.Y. STOCK EXCH., DAILY TAQ CLIENT SPECIFICATIONS 4 (2020), https://www.nyse.com/publicdocs/nyse/data/Daily_TAQ_Client_Spec_v3.3a.pdf [<https://perma.cc/6HDL-AJ65>] ("Daily TAQ (Trades and Quotes) is a set of files that contain all trades and quotes for all issues listed and traded on US regulated exchanges for a single trading day. The Daily TAQ data is derived from the output of the CTA and UTP SIPs (Tape A, Tape B, and Tape C).").

⁴³ *Supra* note 3.

thirty securities that comprise the Dow Jones Industrial Average.⁴⁴ Trades marked as intermarket sweep orders (ISOs) can execute through multiple levels of quotations;⁴⁵ therefore, the sample of trades includes all non-ISO trades for 1,000 shares or less that were completed during normal trading hours and when the NBBO was neither locked or crossed. With these restrictions, the final sample consists of approximately 2 billion trades, of which roughly 830 million were filled in non-exchange venues.

For each trade, price improvement was calculated based on the NBBO prevailing at the time of the trade.⁴⁶ For this purpose, and consistent with Rule 605, the NBBO was determined based on the best bid and offer for each exchange as disseminated by the two SIPs.⁴⁷ Following this procedure, trade direction was then determined using the Lee-Ready

⁴⁴ For a list of the thirty securities that comprise the Dow Jones Industrial Average, see *Dow 30*, CNBC, <https://www.cnbc.com/dow-30/> [<https://perma.cc/67AS-JE45>] (last visited Mar. 22, 2021).

⁴⁵ 17 C.F.R. § 242.611(b)(5) (exempting from the scope of Rule 611 trade-through protection “the execution of an order identified as an intermarket sweep order”); see also DIV. OF MKT. REGUL., U.S. SEC. & EXCH. COMM’N, RESPONSES TO FREQUENTLY ASKED QUESTIONS CONCERNING RULE 611 AND RULE 610 OF REGULATION NMS 1 (2008), <https://www.sec.gov/divisions/marketreg/rule611faq.pdf> [<https://perma.cc/X8YG-XZW6>] (“The ISO exception enables a destination trading center to execute an ISO immediately at its limit price or better, while also requiring that additional ISOs, as necessary, be routed to execute against the full displayed size of any better-priced protected quotations displayed by other trading centers.”).

⁴⁶ As discussed in Bartlett & McCrary, *supra* note 3, at 41–42, the SIPs responsible for processing and disseminating transaction data from market centers include two timestamps for each trade and quote report disseminated since August 2015: a participant timestamp (reflecting the time, generally in microseconds, that a trade or quote update occurred at the market center) and the “SIP” timestamp (reflecting the time, generally in microseconds, that a trade or quote was processed by the relevant SIP). The analysis in this Part uses the participant timestamp to match trades to the NBBO for trades occurring after 2015; for trades occurring before this time period, trades are matched to the NBBO using the SIP timestamp.

⁴⁷ Quote updates that are eligible to establish an exchange’s best offer or best bid include those having a condition of A, B, H, O, R, W, or Y. *Id.* at 42.

procedure,⁴⁸ and price improvement was calculated as the fraction of the quoted half-spread provided to the trade. Thus, for buy orders, price improvement is defined as:

$$PI = \frac{(Best\ Offer-Trade\ Price)}{(Best\ Offer-NBBO\ Midpoint)}.$$

And for sell orders, it is defined as:

$$PI = \frac{(Trade\ Price-Best\ Bid)}{(NBBO\ Midpoint-Best\ Bid)}.$$

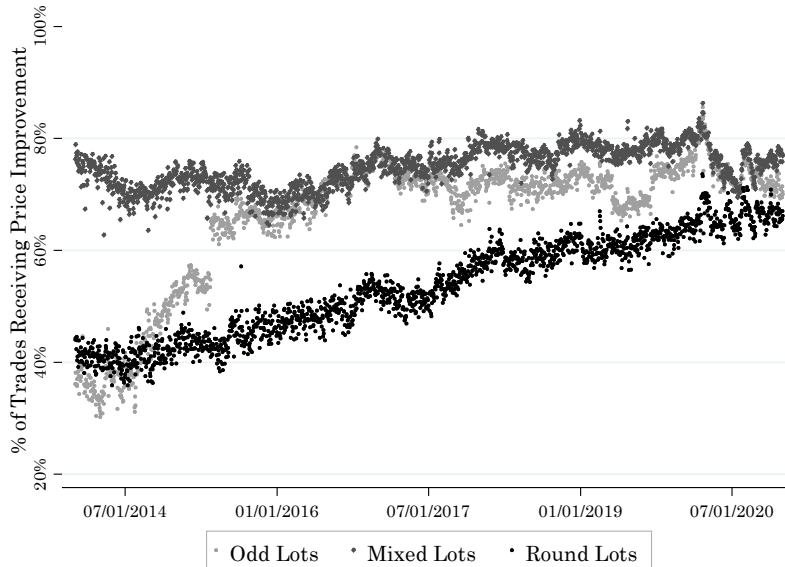
Each trade was also marked with an indicator variable for whether the trade received any price improvement at all.

Figure 4 plots the fraction of trades receiving price improvement on a daily basis between 2014 and 2020 across the following three categories of trades: odd lots (trade size is less than 100 shares), round lots (trade size is a multiple of 100), and mixed lots (all other trades).⁴⁹ Notably, except in 2014, the fraction of non-exchange odd lot trades receiving some amount of price improvement has generally exceeded that of round lot trades. Figure 4 also reveals a sudden jump in the fraction of odd lot trades receiving price improvement on exactly May 6, 2015. More specifically, the rate of price improvement for odd lot trades jumped from 54.8% on May 5, 2015 to 65.2% on May 6, 2015.

⁴⁸ See generally Charles M.C. Lee & Mark J. Ready, *Inferring Trade Direction from Intraday Data*, 46 J. FIN. 733 (1991).

⁴⁹ Round lots are presented separately from mixed lots to account for the large number of trades in trade sizes having a multiple of 100 shares.

Figure 4. Rate of Price Improvement in Non-Exchange Trades in Dow Stocks, 2014–20



The May 6, 2015 increase in price improvement for odd lots may be related to the initiation of a voluntary disclosure regime. Partly in response to the publication of Michael Lewis’s *Flash Boys*⁵⁰ in 2014, the Financial Information Forum (FIF) (a consortium of retail brokerage firms, wholesale market makers, and data providers) assembled a working group to examine trade execution quality for retail trades.⁵¹ In 2015, the initiative resulted in three prominent retail brokerage firms (Charles Schwab, Fidelity, and Scottrade) and four wholesale market makers (Citadel Securities, KCG, Two Sigma Securities, and UBS) committing to release voluntary, enhanced statistics on retail execution

⁵⁰ MICHAEL LEWIS, *FLASH BOYS: A WALL STREET REVOLT* (2014).

⁵¹ See Bill Alpert, *Exclusive: Who Makes Money on Your Stock Trades*, BARRON’S (Feb. 27, 2015), <https://www.barrons.com/articles/exclusive-who-makes-money-on-your-stock-trades-1425103695> [https://perma.cc/2Y LX-FNSX].

quality.⁵² The first reports were released in June 2015, and, in contrast to Rule 605 reports, these reports disclosed average price improvement rates and levels for odd lot trades.⁵³

Overall, consistent with Figure 4, the FIF working group reports revealed that price improvement rates for odd lot trades were substantially lower than for non-odd lot trades for virtually all participants.⁵⁴ Writing for *TABB Forum*, Christopher Nagy of Healthy Markets noted that wholesale market makers had acknowledged the disparity in odd lot price improvement, but that market makers also “claimed that in the coming quarters, Odd Lots will see higher metrics.”⁵⁵ While not all market makers continued to disclose quarterly performance data under the FIF transparency initiative, reports filed by those that did were consistent with this claim and showed a notable increase in price improvement rates for odd lot trades in the ensuing quarters. Table 1, for instance, presents the average improvement rates for odd lot trades disclosed by Citadel (one of the largest wholesale market makers) in its three 2015 FIF reports that remain publicly available.⁵⁶ This sudden increase in price improvement rates by Citadel could account for part of the time trends in Figure 4.

⁵² Nagy, *supra* note 26.

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ *Id.*

⁵⁶ See generally CITADEL SEC. LLC, Q1-2015 FIF SUPPLEMENTAL RETAIL EXECUTION QUALITY STATISTICS (2015) (on file with the Columbia Business Law Review), https://www.citadelsecurities.com/_files/uploads/sites/2/2013/08/FIF-Rule-605-606-WG-CitadelSecurities_Retail-Execution-Quality-Stats_Q1_2015.pdf; CITADEL SEC. LLC, Q2-2015 FIF SUPPLEMENTAL RETAIL EXECUTION QUALITY STATISTICS (2015) (on file with the Columbia Business Law Review), https://www.citadelsecurities.com/_files/uploads/sites/2/2013/08/FIF-Rule-605-606-WG-CitadelSecurities_Retail-Execution-Quality-Stats_Q2_2015.pdf; CITADEL SEC. LLC, Q4-2015 FIF SUPPLEMENTAL RETAIL EXECUTION QUALITY STATISTICS (2016) (on file with the Columbia Business Law Review), https://www.citadelsecurities.com/_files/uploads/sites/2/2013/08/FIF-Rule-605-606-WG-CitadelSecurities_Retail-Execution-Quality-Stats_Q4_2015.pdf.

Table 1. Citadel FIF Disclosures for Odd Lot Trades in S&P 500 Stocks

	2015			
	Q1	Q2	Q3	Q4
Price Improvement (%)	45.33%	77.93%	N/A	99.32%
Average Savings Per Order (\$)	\$0.15	\$0.13	N/A	\$0.28

To the extent these FIF disclosures encouraged wholesale market makers to offer greater price improvement for odd lot trades, the FIF data suggest that the lack of transparency concerning odd lot trade executions may have contributed to the lack of price improvement for odd lot trades prior to 2015. At the same time, the FIF initiative also highlights important limitations of an entirely voluntary disclosure regime. First, many participants chose to refrain from disclosing statistics after 2015 and subsequently left the working group.⁵⁷ As of this writing, FIF lists only one retail brokerage firm (Fidelity) and one wholesale market maker (Two Sigma Securities) as participants in the disclosure program.⁵⁸

⁵⁷ For instance, UBS does not appear to have ever disclosed its retail execution statistics on the FIF website, *see, e.g.*, Retail Execution Quality Statistics, FIN. INFO. F. (on file with the Columbia Business Law Review), <https://web.archive.org/web/20150725075259/https://www.fif.com/> (last visited May 25, 2021) (capturing FIF's collection of execution statistics on July 25, 2015), and was no longer reported as a member of the working group by early 2016. *See* Retail Execution Quality Statistics, FIN. INFO. F. (on file with the Columbia Business Law Review), <https://web.archive.org/web/20160331181259/https://fif.com/> (last visited May 25, 2021) (capturing FIF's collection of execution statistics on March 31, 2015).

⁵⁸ *See Retail Execution Quality Statistics*, FIN. INFO. F., <https://fif.com/index.php/retail-execution-quality-statistics> [<https://perma.cc/K8QW-V96Z>] (last visited Mar. 15, 2021). *But see Rule 605 and 606 Reporting*, VIRTU FIN., <https://www.virtu.com/about/transparency/rule-605-and-606-reporting/#:~:text=Rule%20605%20requires%20%E2%80%9Cmarket%20centers,about%20%E2%80%9Ccovered%20order%E2%80%9D%20executions.> [<https://perma.cc/U6RJ-GCML>] (last visited May 25, 2021) (claiming that Virtu Financial continues to participate).

Second, the choice of execution metric may lead to a misleading depiction of trade execution performance. The typical metric for price improvement follows the Rule 605 report convention, which is the fraction of trades receiving any price improvement.⁵⁹ A problem with this metric is that the overall rate of price improvement may be high, but the amount of price improvement may be de minimis. Indeed, Rule 612 of Reg NMS provides that quotes for more than \$1.00 per share must be made in the minimum price increment of a penny, but it provides that trades may be executed in sub-penny increments in part to enable sub-penny price improvement.⁶⁰ A common amount of price improvement observed in market data is \$0.001 or less per share. The other commonly reported metrics may also provide only partial information. For example, the disclosure of average savings per order does little to rule out the possibility that price improvement rates reflect a market center providing only sub-pennies of price improvement per share. For instance, in Table 1, the \$0.28 of savings per order during the fourth quarter of 2015 would reflect price improvement of \$0.028 per share for a trade of ten shares but just \$0.003 for a trade of ninety shares.

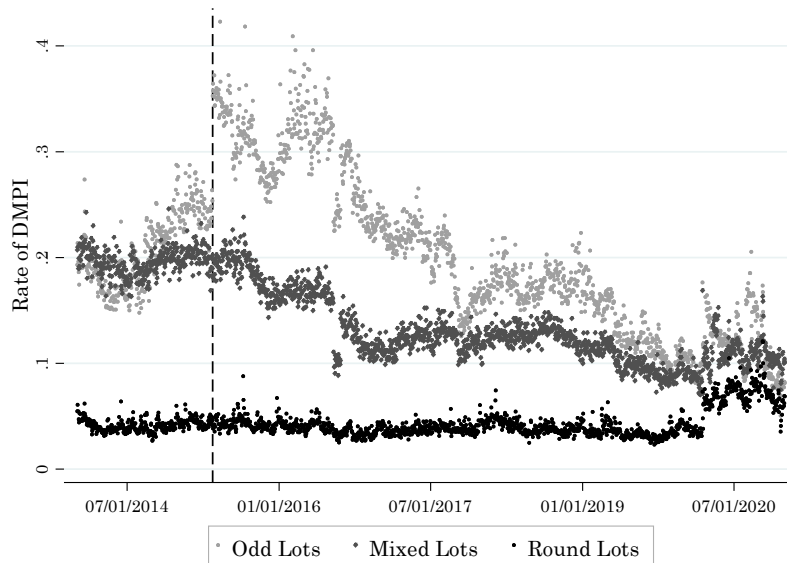
To examine whether the rise in price improvement rates shown in early 2015 may have resulted from an increase in de minimis levels of price improvement, I also examine in Figure 5 the rate of de minimis price improvement for each non-exchange trade. During this time period, the intraday average quoted spread for the Dow Jones 30 was approximately \$0.02 per share. For each trade receiving any price improvement, the trade was labeled as receiving de minimis price improvement (DMPI) if the level of price improvement was less than ten percent of the quoted half-spread of the

⁵⁹ See 17 C.F.R. § 242.605(a)(ii)(B) (2020) (setting forth the convention).

⁶⁰ See *id.* § 242.612(a) (“No national securities exchange, national securities association, alternative trading system, vendor, or broker or dealer shall display, rank, or accept from any person a bid or offer, an order, or an indication of interest in any NMS stock priced in an increment smaller than \$0.01 if that bid or offer, order, or indication of interest is priced equal to or greater than \$1.00 per share.”).

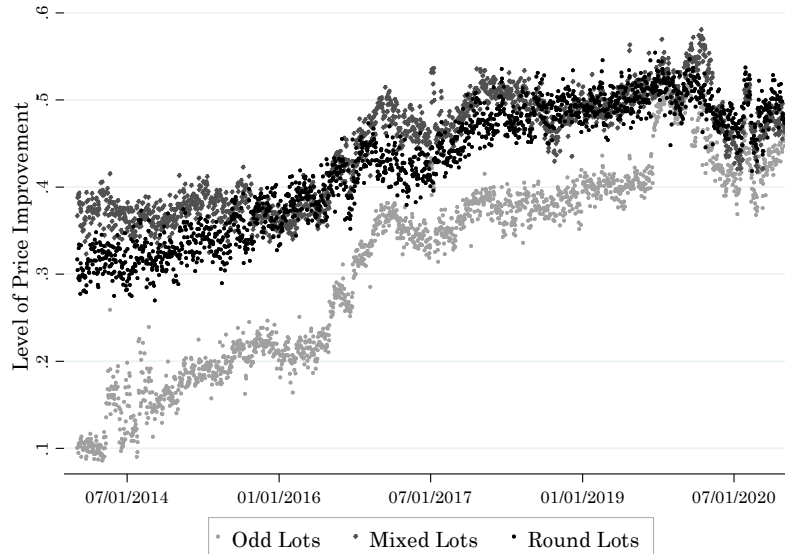
prevailing NBBO. Thus, a trade in a security whose quoted spread is \$0.02 and that receives less than \$0.001 per share of price improvement would be classified as receiving DMPI. The dashed vertical line in Figure 5 represents May 6, 2015. The figure reveals a general increase in DMPI for odd lot trades commencing in 2015, with a sharp, discontinuous increase on exactly May 6, 2015.

Figure 5. Rate of DMPI in Non-Exchange Trades in Dow Stocks, 2014–20



Given the important role of DMPI in the price improvement rates presented in Figure 4, trades were also evaluated based on a trade's overall level of price improvement, as defined above. Figure 6 presents the results. Using this measure, price improvement for odd lots has converged since 2014 to nearly the levels observed for round and mixed lots but persists in being lower than that provided for larger-size trades.

Figure 6. Levels of Price Improvement in Non-Exchange Trades in Dow Stocks, 2014–20



To examine more precisely the extent to which price improvement differs for odd lot trades, I also conduct a regression discontinuity analysis for a large sample of securities during the calendar year 2020. This latter analysis examines the conditional expectation of a given trade receiving price improvement based on its actual trade size.⁶¹ As such, this analysis can be used to derive an empirical estimate of the degree to which odd lot trades in non-exchange venues receive differential rates of price improvement outside the highly liquid securities that comprise the Dow Jones Industrial Average.

To build the sample of securities for this analysis, each trading day in 2020 was separately evaluated to identify all securities whose dollar volume of trades was at least \$5,000,000 during regular trading hours. On any given

⁶¹ For a brief introduction to regression discontinuity analysis, see Bartlett & McCrary, *supra* note 11, at 307–08 (using a regression discontinuity design to examine the effect of changing the minimum price variation for quoting equity securities).

trading day in 2020, this filter resulted in a daily sample of roughly 3,300 securities. As with the previous analysis of the Dow Jones securities, the sample includes all trades occurring in these securities when the NBBO was not locked or crossed. Lastly, price improvement was calculated for each trade having a size of 500 shares or less. With these restrictions, the sample consists of over 12 billion trades, of which approximately 3.1 billion were filled in non-exchange venues.

Visual observation of the data reveals notable clustering of trades at round lot figures, along with “heaping” at trade sizes with “trailing 5s” (205, 210, 215, etc.). To control for differentials in liquidity at these trade sizes, along with the overall number of trades at each trade size, I collect the residuals from a regression of the weighted-average price improvement for each trade size on a flexible function of the number of trades⁶² and the three-way interaction of indicators for two-digit trade size, non-exchange trades, and ISO trades.⁶³ Figure 7 plots these residual values as a function of trade size for trades executed in non-exchange venues.

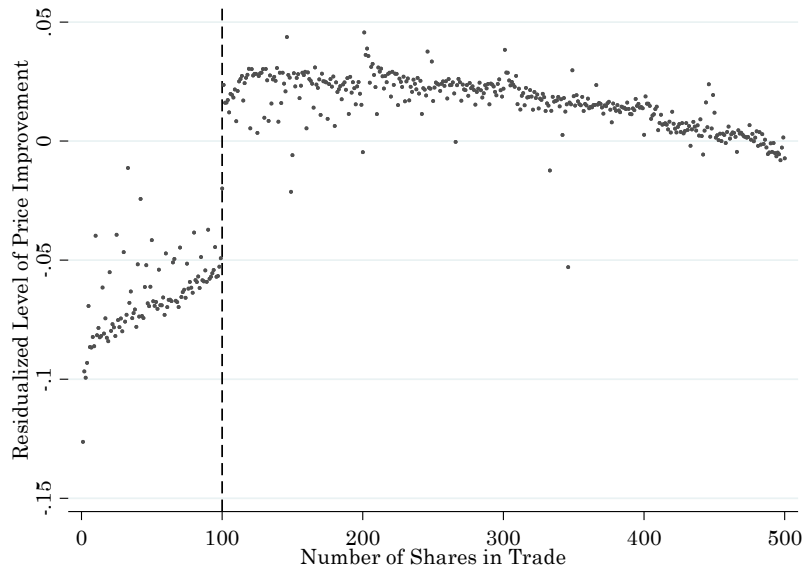
⁶² The specific function used included the natural logarithm of the number of trades as well as the inverse of the number of trades. This fits the data well, leading to an in-sample R-squared of approximately ninety percent.

⁶³ Specifically, I use the following regression specification:

$$PI_{ies} = \alpha + \beta_1 \ln(TT_{ies}) + \beta_2 1/(TT_{ies}) + \beta_3 FINRA_{ies} \times ISO_i \times TDTS_{ies} + \varepsilon_{ies}$$

where i indexes a trade size of 1 to 499 shares, e indexes trades within trade size i that were executed on an exchange versus non-exchange venue, s indexes trades within trade size i that were ISOs versus non-ISOs, PI is the average price improvement for trades indexed by ies (weighted by the number of trades), TT is the number of total trades indexed by ies , $FINRA$ is an indicator for whether trades indexed by ies were executed in an exchange or non-exchange venue, ISO is an indicator for whether trades indexed by ies were intermarket sweep orders, and $TDTS$ is an indicator for the two-digit trade size for trades indexed by ies .

Figure 7. Price Improvement and Trade Size: Non-Exchange Venues



As shown in the figure, the conditional expectation of price improvement falls discontinuously as trade sizes fall below 100 shares. Round lot orders received price improvement amounting to roughly forty-five percent of the quoted half-spread. Therefore, the point estimate of 0.0405 (SE=0.0044) in Figure 7 translates to a statistically significant reduction of price improvement for odd lot trades from approximately forty-five percent to forty-one percent, or approximately ten percent less in the level of price improvement.

Overall, these estimates are consistent with the concern that the challenge of observing odd lot trade execution quality may contribute to inferior trade execution for odd lot trades in non-exchange venues. This conclusion seems especially relevant for retail trade execution in light of the difficulty of monitoring trade execution quality in this context. To be sure, the TAQ data for non-exchange trades includes trades executed by both wholesale market makers and other non-exchange venues such as dark pools. However, the experience of the FIF working group in 2015 stands as a telling

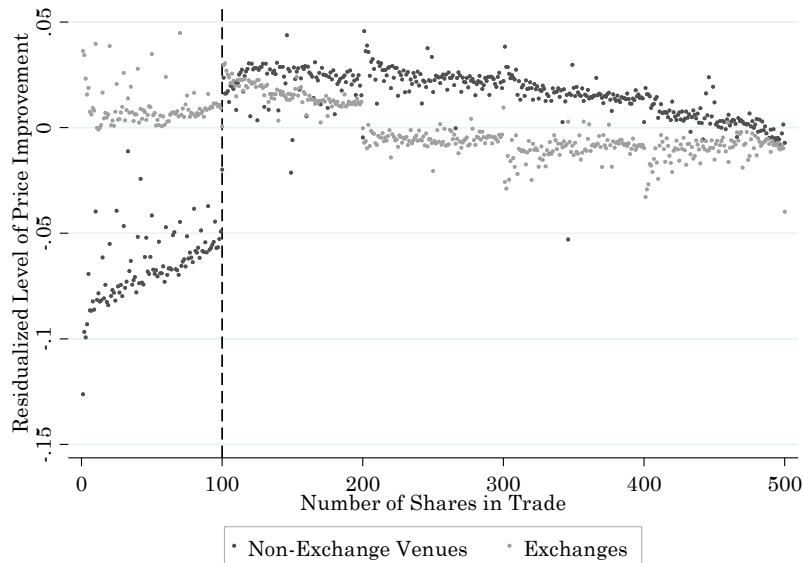
illustration of how enhanced transparency of odd lot trade execution quality can induce wholesale market makers to enhance price improvement for odd lot trades.

Finally, it is important to note that the definition of price improvement used in this Part rests on a critical assumption: that the Reg NMS NBBO is the proper benchmark to use to evaluate pricing and best execution. Yet, as explored in the next Part, there are reasons to question whether this is, in fact, the proper NBBO to use for purposes of evaluating the trade execution quality of odd lot trades.

III. ODD LOTS AND THE NBBO

As discussed in the prior Part, odd lot trades executed in non-exchange venues receive on average less price improvement relative to the Reg NMS NBBO than round lot trades executed in non-exchange venues. The opposite conclusion, however, holds with respect to exchange trades. As an illustration, consider Figure 8, which uses the same data and analysis used for Figure 7 but focuses on exchange trades, which are superimposed on the estimates for non-exchange trades.

Figure 8. Price Improvement and Trade Size: Non-Exchange Venues vs. Exchanges



Aside from a notable increase in price improvement for trades between 100 and 200 shares, price improvement on exchanges generally increases gradually as trade sizes decline. Indeed, expected price improvement on exchanges appears to be especially large for the smallest odd lot trades—the opposite of what occurs for non-exchange trades.

What accounts for the different result for odd lot trades executed on exchanges? Much of the explanation stems from how price improvement occurs for exchange trades. When a given exchange receives an inbound marketable order, Rule 611 requires the exchange to route the order to the venue displaying the national best bid or offer (as applicable) unless a liquidity provider at the exchange is offering liquidity at or better than this price.⁶⁴ If such a liquidity provider is present, the exchange will allow the marketable order to execute

⁶⁴ 17 C.F.R. § 242.611(a)(1). There is an exception when the NBBO changes almost simultaneously with execution. *See id.* § 242.611(b)(8).

against the best priced order on the exchange, observing price-time priority if multiple liquidity providers are quoting at that price.⁶⁵

For orders involving more than ninety-nine shares, the most aggressive displayed quote across exchanges will typically set the national best bid or offer. However, exchanges also allow liquidity providers to post non-displayed quotes,⁶⁶ and some hidden quotes may reflect a price that is more aggressive than the NBBO. Due to these aggressively-priced, non-displayed orders, price improvement will therefore result for a marketable order if it arrives on an exchange that happens to hold such a non-displayed order. Accordingly, one can infer from Figure 8 that the likelihood that a market order hits hidden liquidity is generally increasing as trade sizes step down from the 400s to the 300s to the 200s to the 100s.

This explanation for exchange price improvement, however, is insufficient to explain the large amount of price improvement for many odd lot trades. This is because Rule 611 and the calculation of the NBBO under Reg NMS specifically *exclude* odd lot quotes from consideration.⁶⁷ The large number of price-improved trades on exchanges involving odd lots shown in Figure 8 thus reflects market orders hitting both displayed and non-displayed odd lots posted to exchanges that are priced more aggressively than the official NBBO.

While non-displayed odd lot quotes are omitted from exchange order book data,⁶⁸ exchanges' proprietary data feeds

⁶⁵ See *Explaining Parity / Priority*, NYSE, <https://www.nyse.com/article/parity-priority-explainer> [<https://perma.cc/ET43-ZUFE>] (last visited May 25, 2021) (contrasting the usual price-time priority system with the NYSE's "parity/priority" system).

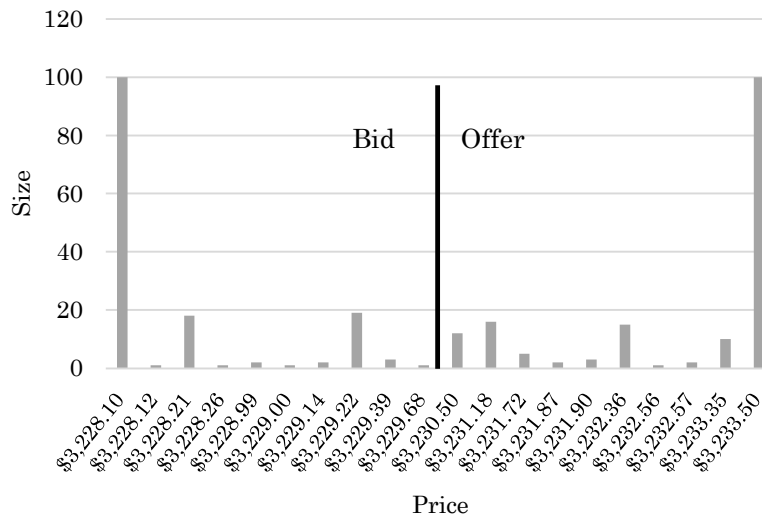
⁶⁶ See Hendrik Bessembinder, Marios Panayides & Kumar Venkataraman, *Hidden Liquidity: An Analysis of Order Exposure Strategies in Electronic Stock Markets*, 94 J. FIN. ECON. 361, 361–62 (2009) (describing exchanges that allow traders to post hidden orders).

⁶⁷ See *supra* notes 19–20 and accompanying text.

⁶⁸ Because non-displayed quotes are hidden orders, they are not included in an exchange's depth-of-book data. See, e.g., MarketInsite, *Depth of Book: Getting the Full View*, NASDAQ (Sept. 27, 2018, 2:22 PM), <https://www.nasdaq.com/articles/depth-of-book%3A-getting-the-full-view->

reveal the importance of displayed odd lot quotes in today's markets. As an illustration, Figure 9 presents the top ten levels of Nasdaq's order book for Amazon on January 27, 2021 at 15:48:03.61382945.⁶⁹ Focusing on orders that comprise at least a round lot of 100 shares, the best bid and offer stood at $\$3,228.10 \times \$3,233.50$, for a spread of $\$5.40$. However, the Nasdaq order book reveals that, based on the actual displayed trading interest, the true best bid and offer was $\$3,229.68 \times \$3,230.50$ —a spread of just $\$0.82$, which is a scant 15% of the round lot spread. Nor were these economically trivial odd lot quotes. Odd lot bids amounted to nearly $\$155,000$ of aggregate trading interest, while odd lot offers amounted to over $\$213,000$ of aggregate trading interest.

Figure 9. Nasdaq Order Book for Amazon (AMZN) at 15:48:03.61382945



2018-09-27 [<https://perma.cc/Q45T-5GMJ>] (explaining that Nasdaq's depth-of-book data "[e]ncompasses all *displayed* orders" (emphasis added)).

⁶⁹ Nasdaq order book data was obtained from the Limit Order Book Reconstruction System (LOBSTER). See *LOBSTER: High-Frequency, Easy-To-Use and Latest Limit Order Book Data for Your Research*, *supra* note 27.

Even before the 2020 Market Data Reform, the increasing levels of displayed odd lot liquidity had naturally caused a number of concerns at exchanges given that this displayed trading interest was unprotected by Rule 611.⁷⁰ For example, a trading venue that receives a marketable order faces no obligation under Rule 611 to route the order to an exchange with aggressively-priced odd lot quotes so long as the trading venue can fill the order at a price that is at or better than the displayed NBBO. As a partial corrective, in late 2018 Nasdaq implemented a policy of aggregating displayed odd lot trading interest into the most aggressive price available for a round lot, and it began disseminating these prices to reflect its best bid or offer.⁷¹ However, the policy nevertheless has resulted in displayed quotations that might ignore meaningful trading interest at superior prices. For instance, applying Nasdaq's policy to the data in Figure 9 would not result in aggregation of either odd lot bids or offers because the total aggregated odd lot depth on either side of the market would be less than 100 shares.

Exchanges' concerns about the trading-through of displayed quotes also highlights the risk that marketable orders face in non-exchange venues. To comply with Rule 611, a dark pool or internalizer that receives an inbound marketable order might fill an order at the Reg NMS NBBO despite the availability of better pricing from odd lot quotes

⁷⁰ See, e.g., Investors Exchange LLC; Notice of Filing and Immediate Effectiveness of a Proposed Rule Change To Modify the Way It Handles Odd Lot Orders by Allowing them To Be Displayed Orders and To Aggregate To Form a Protected Quotation, 86 Fed. Reg. 6,687, 6,688–89 (Jan. 22, 2021) (noting that “odd lots are not subject to the same requirements as round lot orders under Regulation NMS, primarily in that only round lots can be protected quotations” and proposing modification to exchange rules to permit the aggregation of displayed odd lot orders at price points that equal at least one round lot).

⁷¹ See *Equity Trader Alert #2018 - 87*, NASDAQTRADER.COM (Nov. 2, 2018), <https://www.nasdaqtrader.com/TraderNews.aspx?id=ETA2018-87> [<https://perma.cc/7KMM-XEUL>]; The Nasdaq Stock Market LLC; Notice of Filing and Immediate Effectiveness of Proposed Rule Change To Amend Rule 4756(c)(2), 83 Fed. Reg. 62,633, 62,633–34 (Dec. 4, 2018).

posted to exchanges. Of course, after the 2020 Market Data Reform, the four-tier definition⁷² of a round lot will often allow quotes for less than 100 shares to establish the NBBO and receive price protection for certain securities. However, the vast majority of securities have security prices that are lower than \$250 per share,⁷³ and for these securities, the definition of a round lot will remain unchanged.⁷⁴ Moreover, even for Amazon, a round lot under the 2020 Market Data Reform will consist of an order for at least ten shares based on Amazon's current stock price.⁷⁵ Applying this rule to Figure 9, the best offer for twelve shares at \$3,230.50 could establish the national best offer and receive price protection. However, the best bid for Nasdaq would be displayed at \$3,229.22 (or \$0.46 less than the best odd lot bid), which represents the most aggressive price that would satisfy quotes for ten shares. Overall, the displayed bid-ask spread for Nasdaq would therefore be \$1.28, or approximately 156% of the actual spread due to the continued presence of odd lot quotes.

Thus, even after the 2020 Market Data Reform, marketable orders received by a non-exchange venue will still face the risk of price dis-improvement if a non-exchange venue receiving the order simply fills the order at (or slightly better than) the Reg NMS NBBO. This is particularly true for high-priced stocks where the spread of the price-protected NBBO is likely to be much larger than a penny, thereby allowing traders to post odd lot quotes inside the NBBO.

⁷² See *supra* notes 28–29 and accompanying text.

⁷³ For example, 97.8% of the 7,752 securities with non-zero trading volume in the stock file of the Center for Research in Security Prices had a closing price of less than \$250 on December 31, 2020. On these data, see *Research Data*, CTR. FOR RSCH. IN SEC. PRICES, LLC, <http://www.crsp.org/products/research-products> [<https://perma.cc/CN7P-T2V9>] (last visited May 25, 2021).

⁷⁴ See *supra* note 29.

⁷⁵ As of May 2021, Amazon's stock price hovered around \$3,000 per share, see Amazon.com, Inc. Historical Data, YAHOO! FIN., <https://finance.yahoo.com/quote/AMZN/history?p=AMZN> [<https://perma.cc/W664-DBAL>] (last visited May 25, 2021), putting it well within the category of securities that will have a round lot defined to be ten shares. See *supra* note 29.

To assess the relevance of this issue for internalized retail trades in high-priced securities, I turn to the Nasdaq order book data for January 27, 2021 for Amazon and GameStop. I focus on trades in these two securities on this day as each represented the type of security for which odd lot quotes were likely to exist within the Reg NMS NBBO. Specifically, on January 27, 2021, the per share cost of a share of Amazon was approximately \$3,000, and its (price-protected) quoted spread was roughly \$3.00, while the cost of a share of GameStop was approximately \$300, and its (price-protected) quoted spread was roughly \$1.40. Moreover, GameStop's emergence as a popular retail stock and its related surge in price by January 27⁷⁶ provide an opportunity to explore the extent to which the 2020 Market Data Reform leaves retail trades in so-called "meme" stocks subject to the risk of deficient trade execution, at least as measured by available odd lot quotations.

To construct the sample of retail trades for these two securities, I rely on the fact that non-exchange trades executed at sub-penny prices that differ from the midpoint of the NBBO are very likely to represent internalized retail trades.⁷⁷ This result arises from the fact that Rule 612

⁷⁶ GameStop's stock price surged from roughly \$20 per share in early January 2021 to over \$300 per share during the final week of January 2021 in a rally reportedly fueled by retail trading and delta hedging of call options. See John Foley, *Breakdown: GameStop, a Financial Markets Whodunnit*, REUTERS (Jan. 28, 2021, 3:23 PM), <https://www.reuters.com/article/us-retail-trading-breakingviews-idUSKBN29X2SV> [<https://perma.cc/2KB9-R94F>].

⁷⁷ This proxy for retail trades is also adopted in Ekkehart Boehmer et al., *Tracking Retail Investor Activity*, J. FIN. (forthcoming) (manuscript at 7) (on file with the Columbia Business Law Review), <https://onlinelibrary.wiley.com/doi/epdf/10.1111/jofi.13033>. As noted by Megan Shearer, the primary limitation of this approach is that it may also capture orders filled by single dealer platforms (SDPs), which internalize orders from institutional investors. Cf. Megan Shearer, *The Phases and Catalysts of Mini Flash Crashes* 29 (Aug. 24, 2020) (unpublished manuscript) (on file with the Columbia Business Law Review), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3434728. The risk of misclassification, however, should be diminished by limiting the analysis to small odd lot trades, as well as by the restriction that price improvement can be no more than \$0.001 from the NBBO.

exempts trades from the prohibition on sub-penny prices,⁷⁸ and recent SEC enforcement actions against several dark pools (which also report as non-exchange venues) have limited the use of “pegged” orders to those that are pegged to the near, far, and midpoint of the NBBO.⁷⁹ Thus, trades reported as having only modest sub-penny price improvement relative to the Reg NMS NBBO are very likely to represent the internalized retail trades of interest for this analysis. Existing research suggests retail price improvement is on the order of a hundredth of a penny or less;⁸⁰ therefore, the sample includes all non-exchange odd lot trades in Amazon and GameStop having \$0.001 or less of price improvement relative to the Reg NMS NBBO.⁸¹ While this filter results in excluding many trades, it has the benefit of isolating those odd lot trades that are most likely to be internalized retail orders.

Following this step, each odd lot trade was then evaluated against the prevailing Reg NMS NBBO, along with an alternative calculation of the NBBO that incorporates odd lot quotes at Nasdaq—the “Odd Lot” (OL) NBBO. The OL NBBO was constructed by defining the OL best bid or offer to be the Nasdaq bid or offer (as applicable) whenever the Nasdaq quote would offer superior pricing relative to the conventional Reg NMS NBBO. Otherwise, the OL best bid or offer equals the

⁷⁸ See 17 C.F.R. § 242.612(a) (2020) (regulating “display, rank[ing], or accept[ance]” of “a bid or offer, an order, or an indication of interest” but not trade execution).

⁷⁹ See Bartlett & McCrary, *supra* note 11, at 292.

⁸⁰ Shearer, *supra* note 77 (manuscript at 29).

⁸¹ This approach differs from Boehmer et al., *supra* note 77 (manuscript at 3), who classify retail trades simply by the fraction of a penny associated with a trade’s price. As they note, this approach works within their dataset given that the average quoted spread is roughly \$0.01. *Id.* (manuscript at 7). However, this is not the case for Amazon or GameStop, and adopting this approach would include many trades receiving several dollars of price improvement relative to the NBBO, which suggests that these trades reflect other permissible sub-penny transactions (e.g., a trade by an SDP or a volume-weighted pricing algorithm within a dark pool). As a result, a trade is flagged as a potential retail trade if it has \$0.001 or less of price improvement. In addition, a trade is excluded from the sample if the Reg NMS NBBO is locked or crossed at the time of its execution based on the participant timestamp of the trade.

Reg NMS best bid or offer. Each trade in the sample was then compared to both the Reg NMS NBBO and the OL NBBO to determine whether it would have received superior pricing at the OL NBBO, as well as how much price improvement was provided to it when using the Reg NMS NBBO versus the OL NBBO as the relevant benchmark.

Table 2 illustrates this process using a non-exchange trade for two shares in Amazon occurring at 09:39:42.293. As shown in the Table, the trade appears to have reflected a marketable sell order that was executed at \$3,283.4901, which was \$0.0001 better than the national best bid as calculated pursuant to Reg NMS. As such, the two-share trade received \$0.0002 of price improvement using the Reg NMS NBBO as the benchmark. At the time, however, the best bid and offer at Nasdaq stood at \$3,287.27 × \$3,289.69 due to a bid for six shares at \$3,287.27 and an offer for 100 shares at \$3,289.69. Compared to the Reg NMS NBBO, Nasdaq offered better pricing on the bid but was tied on the offer; therefore, the OL bid in this case equals the Nasdaq bid, and the OL offer equals the Reg NMS best offer. Looking at the trade price and the two versions of the NBBO, it is clear that there is a small amount of price improvement if the Reg NMS NBBO is the benchmark, but the trade would have received better pricing had it been filled at the OL best bid. In particular, it would have received \$7.7598 more had it been filled at the OL best bid (i.e., $2 \times (\$3,287.37 - \$3,283.4901) = \$7.7598$).

Table 2. Illustration of Odd Lot (OL) NBBO Construction

<i>Observed Trade</i>							
Time	Ex	Size	Price				
09:39:42.293	D	2	3283.4901				
<i>Best Bids and Offers at Time of Trade Execution</i>							Price
NMS BBid	NMS BOffer	Nasdaq BBid	Nasdaq BOffer	OL BBid	OL BOffer	Improvement Using OL NBBO	
3283.49	3289.69	3287.37	3289.69	3287.37	3289.69	-7.7598	

Note that because Nasdaq represents just one exchange that may be holding price-improving odd lot quotes, the calculation of the OL NBBO would likely be higher for the bid and lower for the offer if this analysis included odd lot quotations for Amazon across all sixteen exchanges' proprietary data feeds. The estimated differences between the Reg NMS NBBO and the OL NBBO should therefore be viewed as conservative estimates of the extent to which the NBBO would narrow were it to include all odd lot quotes.

On January 27, 2021, there were a total of 3,051 odd lot trades for Amazon common stock that met the above-mentioned definition for a price-improved retail trade. Applying the foregoing approach to all of these trades reveals that 947 trades (31%) would have received better pricing had the trade been filled at the Nasdaq OL NBBO. These 947 trades consisted of 448 marketable sell orders that would have received approximately \$2,616 more in proceeds had the trades been filled at the OL best bid and 449 marketable buy orders that would have saved approximately \$2,420 had the trades been filled at the OL best offer. Overall, the full set of 3,051 trades received an aggregate of \$3.5807 in price improvement relative to the Reg NMS NBBO; however, using the OL NBBO as the relevant benchmark, these trades received aggregate price dis-improvement of roughly -\$5,034.

While non-exchange venues routinely fill trades at the NBBO even at sizes that exceed the NBBO's quoted depth,⁸² a reasonable concern may be whether there was sufficient depth at the OL NBBO to cover the full sizes of these trades. Therefore, the foregoing analysis was also repeated with a requirement that an odd lot quote have sufficient depth to fill all or part of the reported trade. For example, consider Table 3, which analyzes a trade for twelve shares of Amazon that

⁸² For example, in unreported results, approximately thirty percent of all 2020 non-exchange trades in the Dow 30 having a trade size of at least 100 shares and a trade value of \$10,000 or less were completed at the price of the NBBO despite the fact that the trade size was greater than the NBBO's quoted depth. Trades executed at prices outside the NBBO were excluded from this analysis.

occurred at 09:39:13.636. This order to sell was executed at a price of \$3,278.0001 when the Reg NMS best bid was \$3,278.00, yielding \$0.0001 per share of price improvement based on the Reg NMS NBBO. At the time of the trade, however, the first level of bids at Nasdaq displayed bids for six shares at \$3,282.69, and the second level of bids displayed bids for eighteen shares at \$3,281.21. In this alternative calculation of price improvement, I therefore matched half of this twelve share trade at \$3,282.69 and half at \$3,281.21, resulting in price improvement of -\$47.3988.⁸³

Table 3. Price Improvement Using the OL NBBO After Accounting for Depth

<i>Observed Trade</i>						
Time	Ex	Size	Price			
09:39:13.636	D	12	3278.0001			

<i>Best Bids and Offers at Time of Trade Execution</i>						
NMS	NMS	Nasdaq	Nasdaq	Nasdaq	Nasdaq	Price
BBid	BOffer	BBid	Depth	BBid	Depth	Improvement
		Level 1	Level 1	Level 2	Level 2	Using OL NBBO
3278.00	3286.05	3282.69	6	3281.21	18	-47.3988

⁸³ More specifically, price improvement was calculated for this trade as: $6 \times (\$3,278.0001 - \$3,282.69) + 6 \times (\$3,278.0001 - \$3,281.21) = -47.3988$. In the event that the full size of a trade could not be matched to an order level within the NBBO, I assumed that the unmatched portion of the trade should be evaluated against the Reg NMS NBBO for purposes of calculating price improvement. For example, if the trade in Table 3 were for fifty shares (instead of twelve shares), and if the next level of Nasdaq bids were at \$3,278 (i.e., the Reg NMS bid), price improvement for this trade would be calculated as: $50 \times \$3,278.0001 - (6 \times \$3,282.69 + 18 \times \$3,281.21 + 26 \times \$3,278) = -\$85.91$. For purposes of this analysis, I examined only the first ten levels of Nasdaq's order book.

After applying this alternative analysis to the 947 trades completed when the top of the Nasdaq book had superior prices to the Reg NMS NBBO, the 448 marketable sell orders would have received approximately \$1,690 more in proceeds based on Nasdaq's order book prices, while the 449 marketable buy orders would have saved approximately \$1,433. Overall, based on this alternative approach, using the OL NBBO as the relevant pricing benchmark shows aggregate price dis-improvement across all 3,051 retail trades of approximately -\$3,123.

Turning to GameStop, on January 27, 2021 there were 232,967 odd lot trades that met the foregoing definition of a non-exchange retail trade. Of these, 107,940 (46%) would have received better pricing had the trade been filled at the Nasdaq OL NBBO. These 107,940 trades consisted of 29,222 marketable sell orders that would have received approximately \$84,039 more in proceeds had the trade been filled at the OL best bid, and 78,718 marketable buy orders that would have saved approximately \$122,237 had the trade been filled at the OL best offer. The aggregate price improvement for all 232,967 trades was \$238 based on the Reg NMS NBBO; however, using the OL NBBO as the relevant benchmark, these trades collectively received price dis-improvement of approximately -\$206,0000.

As with Amazon, price improvement was also calculated using the alternative procedure that required that the OL NBBO have sufficient depth to cover all or a portion of the trade's size. Under this alternative approach, the 107,940 trades completed when the OL NBBO offered superior pricing to the Reg NMS would have benefited by approximately \$101,000 had the trade been filled (in whole or in part) at prices displayed in Nasdaq's order book. Specifically, the 29,222 marketable sell orders would have received approximately \$36,436 more in proceeds, and the 78,718 marketable buy orders would have saved approximately \$64,645. Overall, based on this alternative approach, using the OL NBBO as the relevant pricing benchmark shows aggregate price dis-improvement across all 232,967 trades of approximately -\$100,879.

Given the conservative approach to defining retail trades in these analyses, these figures capture just a fraction of the total number of odd lot trades in either Amazon or GameStop. Nevertheless, they are strongly suggestive that wholesale market makers execute trades that are benchmarked to the Reg NMS NBBO even when superior pricing exists through odd lot quotes on exchanges.

IV. FIXING THE ODD LOT PROBLEM

As noted in the Introduction, the odd lot problem is rooted in the exclusion of orders for less than 100 shares from Rule 605 and the exclusion of odd lot quotes from the definition of “bid” or “offer” within Reg NMS. Having now presented empirical evidence of the scope of the problem, fixing it might appear to be as straightforward as eliminating these regulatory exclusions. While this conclusion is largely correct with respect to traditional odd lot trades under Rule 605, a slightly more nuanced analysis is required to address odd lot quotes.

With respect to Rule 605, the continued exclusion of odd lot trades from the rule is remarkably outdated, and it is difficult to articulate compelling policy reasons for treating odd lot trades differently than larger trades. On the contrary, trades for fewer than 100 shares now comprise over half of all reported trades,⁸⁴ and Part II reveals that these trades systematically receive lower levels of price improvement than trades for 100 shares or more. The experience of the FIF working group also indicates that industry participants are cognizant of the value of providing traders with trade execution statistics for small orders, and the sudden increase in price improvement rates for odd lot trades in May 2015 suggests improved disclosure may improve odd lot trade execution quality.⁸⁵

Rather, the primary challenge in reforming Rule 605 is in defining what other reforms one might include in such an endeavor. As has been noted by others, the absence of odd lot

⁸⁴ See *supra* note 7 and accompanying text.

⁸⁵ See *supra* text accompany notes 50–56.

trades from Rule 605 reports is but one way in which the evolution of U.S. equity markets has made Rule 605 look increasingly outdated.⁸⁶ Most notably, Rule 605 was finalized in November 2000 as Rule 11Ac1-5,⁸⁷ but it has not been updated to account for the revolution in trading speed that has occurred over the past twenty years. As a result, its rules for calculating trading costs are out of step with the speed with which prices change in modern equity markets. For instance, Rule 605 continues to require that realized spreads be calculated using the midpoint price that prevails five minutes after the time of order execution,⁸⁸ notwithstanding empirical research indicating that in electronic markets realized spreads should be measured in the seconds—and even the microseconds—following a trade.⁸⁹ Likewise, venues are to report their fastest trades according to whether they were “executed from 0 to 9 seconds after the time of order receipt.”⁹⁰ And effective spreads are to be calculated based on the midpoint “at the time of order receipt”⁹¹—a term defined to be

⁸⁶ For instance, several comment letters on the 2020 Market Data Reform suggested the need to update Rule 605. *See, e.g.*, Virtu Fin., Inc., *supra* note 38, at 4 (“[M]any of the Rule 605 execution quality share buckets now bear little relation to the average trade sizes sent by the majority of investors. . . . [A] significant overhaul of Rule 605 would be necessary, including possibly expanding measurement of execution quality to include depth of book.”).

⁸⁷ Disclosure of Order Execution and Routing Practices, 65 Fed. Reg. 75,414, 75,436–38 (Dec. 1, 2000) (codified as amended at 17 C.F.R. § 605 (2020)) (publishing the November rule).

⁸⁸ *See* 17 C.F.R. § 242.600(b)(7) (giving the formula); *id.* § 242.605(a)(1)(i)(K) (requiring disclosure based on the formula).

⁸⁹ For instance, in separate work, Justin McCrary and I illustrate both the feasibility and the relevance of estimating realized spreads in the microseconds occurring after a trade. *See generally* Robert P. Bartlett III & Justin McCrary, *Subsidizing Liquidity with Wider Ticks: Evidence from the Tick Size Pilot Study*, 17 J. EMPIRICAL LEGAL STUD. 262 (2020); Craig W. Holden & Stacey Jacobsen, *Liquidity Measurement Problems in Fast, Competitive Markets: Expensive and Cheap Solutions*, 69 J. FIN. 1747 (2014) (estimating the term structure of realized spreads in the seconds and milliseconds following a trade).

⁹⁰ *See* 17 C.F.R. § 242.605(a)(1)(F).

⁹¹ *Id.* § 242.600(b)(6).

“the time (to the second) that an order was received by a market center for execution.”⁹² In short, the execution statistics at the center of Rule 605 remain stuck in a world that evaluated trades across seconds, even though market prices today can change across microseconds and nanoseconds.⁹³

To understand how this antiquated approach to trading speed can undermine a market center’s statistics one needs to look no further than trading in GameStop on January 27, 2021. Analysis of the TAQ data reveals that GameStop’s NBBO changed at least four times within the second in more than eighty percent of the 60,000 seconds that comprised the trading day. Moreover, the rate of within-second changes could reach dizzying levels, with its NBBO changing over 500 times within the second in eleven instances and changing over 1,500 times in five instances. Such within-second volatility creates considerable discretion for a market center regarding *which* midpoint price to use in complying with Rule 605.

Consider an example. At 11:06:27 on January 27, 2021, a non-exchange purchase of one share of GameStop occurred at a price of \$379.5985 when the contemporaneous Reg NMS NBBO (matched by the microsecond of the trade and quote) was $\$378.12 \times \379.79 , for a midpoint of \$378.955. Based on the NBBO at the microsecond of the trade, the effective spread for this trade was \$1.287. However, due to within-second variation of the NBBO, the midpoint went as high as \$379.215 during 11:06:27, and using this midpoint as the effective spread benchmark, the effective spread for the trade would be only \$0.767.

While it is unclear if market centers select midpoint benchmarks in this fashion, the fact that Rule 605 would appear to permit them to do so is clearly poor regulatory design. Moreover, the shortcomings of regulatory design in this regard are not limited to a volatile stock such as GameStop on January 27, 2021. For instance, even on a light

⁹² *Id.* § 242.600(b)(79).

⁹³ See Holden & Stacey, *supra* note 89, at 1782 (projecting nanosecond response times in the 2020s).

trading day such as December 24, 2020, the TAQ data reveal that the NBBO for Apple changed more than ten times per second for half of all seconds of the trading day, with the NBBO changing 749 times for the second at 3:50:12 pm. Thus, reforming Rule 605 requires not just expanding the rule to cover traditional odd lot trades but also updating it to account for the speed with which prices change in today's equity markets.

The need for Rule 605 to account for the "correct" NBBO midpoint at the time of a trade also implicates the question of the proper regulatory treatment of odd lot quotes. In the previous GameStop example, the NBBO and its midpoint were calculated by reference to the Reg NMS NBBO and not by reference to the "odd lot" NBBO discussed in Part III. At the time of the trade noted above, however, an offer to sell three shares for \$379.69 existed on Nasdaq. Therefore, had the NBBO accounted for odd lot quotes at Nasdaq, it would have been $\$378.12 \times \379.69 , and the effective spread would have increased to \$1.387. In this regard, updating Rule 605 to account for traditional odd lot trades will also require a determination of how to treat odd lot quotes.

From the perspective of promoting best execution of trades, the findings presented in Part III point to the value of including odd lot quotations in the NBBO and protecting them from trade-throughs under Rule 611. The SEC and FINRA have clearly stated that the duty of best execution requires a broker to consider displayed odd lot quotes, and the stated purpose of disclosing (unprotected) odd lot quotes in the 2020 Market Data Reforms is to ensure that odd lot quotations are considered in this regard.⁹⁴ Yet as shown in Part III, odd lot

⁹⁴ See Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,753 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249) ("[T]he inclusion of odd-lot quote information in core data will improve transparency and reduce information asymmetry between market participants who already receive this information through proprietary DOB feeds and market participants who choose to subscribe to this aspect of core data and previously did not receive this information. This could potentially lead to these market participants being able to reduce their execution costs, make more informed trading decisions, facilitate best execution, as well as realize gains from trade." (footnote omitted)); *cf. also* FINRA R. 5310 supp. .06 (Fin. Indus.

quotes today appear to be traded through with regularity, despite the fact that odd lot quotation data is already available through exchanges' proprietary data feeds utilized by the primary wholesale market makers.⁹⁵ To be sure, it is possible that these trade-throughs occur because a venue does not have access to these data feeds; however, the comments received as part of the 2020 Market Data Reform also indicated the extent to which market participants feel compelled to purchase these data (often at extraordinary cost) due to the additional data they contain relative to the public SIP data.⁹⁶

Accordingly, while the expansion of the consolidated "core" data to include odd lot quotes and depth-of-book information will ensure greater access to these data, the findings in Part III nevertheless provide a reason to question whether adding odd lot quotes to the core consolidated data will ensure that they are used for pricing trades. To the extent the goal is to ensure that traders benefit from aggressively-priced odd lot quotes, it would therefore be more effective to include displayed odd lot quotes in the set of quotes eligible for the NBBO and for Rule 611. This conclusion is especially compelling for odd lot trades. In the example given above, the liquidity-taking trade was itself an order to buy a single share of GameStop. Allowing the broker executing this order to ignore the offer to sell three shares for \$379.69 would thus seem, setting aside specialized considerations that might be present in isolated circumstances, to be inconsistent with a policy goal of ensuring best execution.⁹⁷

Yet even for larger market orders, odd lot quotes represent relevant information regarding market conditions. The regulatory preference for round lots is not because odd lot

Regul. Auth. 2021) (describing the need to search for pricing and liquidity information).

⁹⁵ See *supra* note 22 and accompanying text.

⁹⁶ See *supra* note 31.

⁹⁷ See Jonathan R. Macey & Maureen O'Hara, *The Law and Economics of Best Execution*, 6 J. FIN. INTERMEDIATION 188, 220 (1997) ("[A]bsent an explicit demonstration of other offsetting costs, the duty of best execution requires that the trade execute at the best prevailing price.").

orders are economically irrelevant. Rather, the preference dates back to the years following the Civil War, when the fixed costs of floor trading on the New York Stock Exchange made it physically challenging for brokers to handle the expanding number of orders for smaller lots.⁹⁸ The result was a two-tiered market where orders in excess of 100 shares interacted on the floor of the NYSE while odd lot orders were sent to a small group of “odd lot brokers” who specialized in filling odd lot orders on a principal basis (for which they charged an “odd lot differential”).⁹⁹ These concerns are obsolete in modern equity markets, where trade executions occur electronically. Indeed, part of the growth of odd lot trading and quoting is the emergence of smart order routers that are capable of dividing large institutional trades into smaller orders that can seek better pricing within the official NBBO, such as by interacting with odd lot quotes.¹⁰⁰ Thus, even for a large institutional order, aggressively-priced quotes—whether odd lot or round lot—are part of the order book that a trader can “walk through” if it demands more shares than a given price level can provide. Perhaps unsurprisingly, most developed equity markets outside of the U.S. do not distinguish between odd lots and round lots and trade in integer shares.¹⁰¹

To be sure, providing equal treatment to all quotes does call into question the relevance of the NBBO when one or both

⁹⁸ See Henry Brodie, *Odd-Lot Trading on the New York Stock Exchange and Financial Decentralization*, 6 S. ECON. J. 488, 489 (1940). Prior to the Civil War, the NYSE “had no prescribed unit of trading,” and “[a]ll purchases and sales of stock, irrespective of the number of shares involved were executed by brokers at a mutually satisfactory price, through a system of bids and offers on the floor of the exchange.” *Id.*

⁹⁹ See *id.* at 489–90. The price that an odd lot broker used to fill an odd lot order was fixed by the prices at which round lots were sold on the floor of the exchange; consequently, they were not viewed as contributing to price discovery. *Id.* at 490.

¹⁰⁰ For a brief overview of smart order routing, see Kiersten Zaza, *A Fiduciary Standard as a Tool for Dark Pool Subscribers*, 18 STAN. J.L. BUS. & FIN. 319, 330–31 (2013).

¹⁰¹ Phil Mackintosh, *Real Impact of No Round Lots*, TRADERS MAGAZINE (July 20, 2021), <https://www.tradersmagazine.com/am/real-impact-of-no-round-lots/>.

sides of the market can be set by small, odd lot quotes. For instance, a trader looking to sell 500 shares may have concerns that the best bid does not actually represent the price the trader can obtain if the bid is only for a single share. This challenge, however, is simply an extension of an existing problem faced by traders given that the top of the book can already be set by an order for just 100 shares. More importantly, it can be addressed by the availability of depth-of-book data that will soon be disseminated by the consolidated quote and trade system following the 2020 Market Data Reform.¹⁰²

As an example, consider a hypothetical trader looking to sell 500 shares in the market depicted in Table 4. The best bid is \$100.00, but there are only fifteen shares on it. Consequently, without depth-of-book data, the trader may reasonably question whether this is an appropriate benchmark to use for evaluating the market for an order to sell 500 shares. Likewise, the broker who executes the trade may have concerns about reporting an effective spread based on a midpoint price set by a bid of fifteen shares and an offer of just two shares. However, the ability to see multiple levels of prices alleviates both concerns. First, the three levels of bid prices highlight for the trader that a 500-share order would sweep through the first two levels and part of the third for total proceeds of \$49,992.30, or \$99.9846 per share. Second, the broker could provide an execution quality statistic based on this weighted-average price for a 500-share trade. For instance, if the broker internalized the trade at a price of \$99.99, it could report price improvement of \$0.0054 per share.

¹⁰² Market Data Infrastructure, 86 Fed. Reg. 18,596, 18,602 (Apr. 9, 2021) (to be codified at 17 C.F.R. pts. 240, 242, 249).

Table 4. Hypothetical Order Book

Hypothetical Order Book		
Shares to Buy	Price	Shares to Sell
	\$101.06	110
	\$101.05	80
	\$100.04	2
15	\$100.00	
200	\$99.99	
300	\$99.98	

In this fashion, the availability of depth-of-book data should greatly reduce concerns with eliminating the disparate regulatory treatment of odd lot quotes. Moreover, for purposes of reforming Rule 605, they can also be used to calculate size-weighted bid or offer prices that provide a more informative trade execution metric than the NBBO.

V. CONCLUSION

Traditional odd lots now constitute a majority of all trades, but their exclusion from Rule 605 and the definition of a “bid” or “offer” places them at a heightened risk for inferior trade execution. This risk is especially high for odd lot trades filled by wholesale market makers given the difficulty customers face in monitoring trade execution quality in this context.

Using recent trading data, the foregoing analyses illustrate why this risk is not simply theoretical. Traditional odd lot trades systematically receive less price improvement in non-exchange venues than larger orders. Likewise, a sizeable fraction of non-exchange retail trades in Amazon and GameStop on January 27, 2021 were filled at prices that were inferior to the odd lot quotes prevailing on Nasdaq. Moreover, because Nasdaq is but one of sixteen exchanges where superior odd lot quotes might be posted, one should view these findings as conservative estimates of the extent that non-exchange venues may be trading through better priced odd lot quotes on display at exchanges. Overall, these findings point to the need to reform Rule 605 to include smaller orders and

to eliminate the distinction between odd lots and round lots that exists throughout Reg NMS.