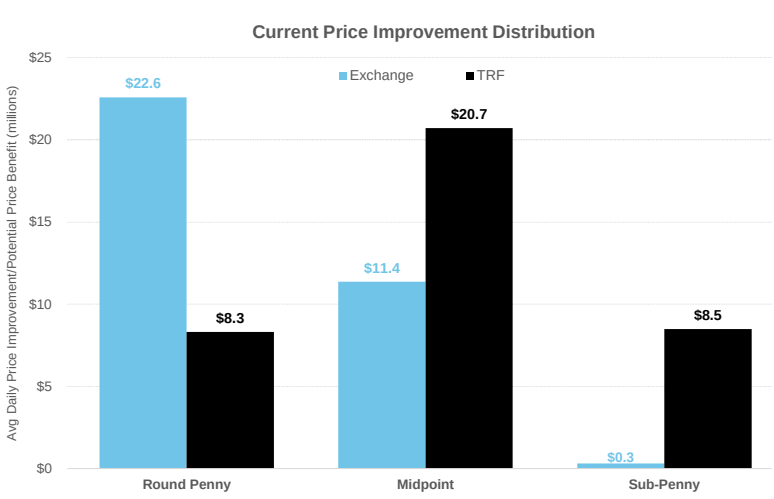
Price improvement, tick harmonization & investor benefit

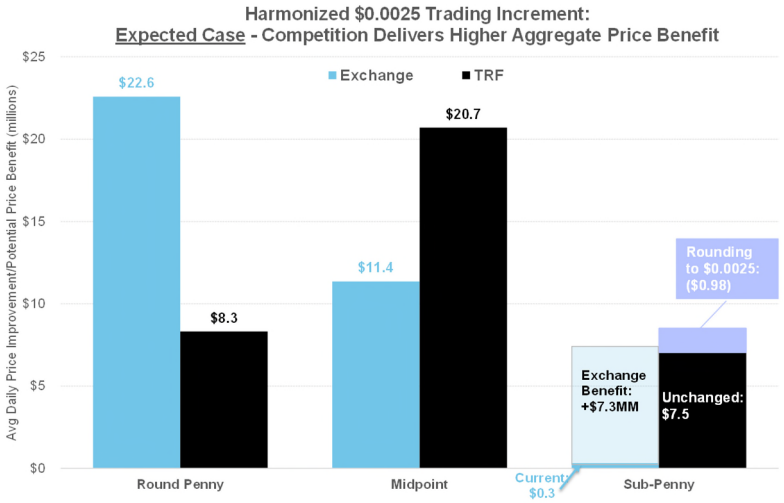
22 August 2022

1. Introduction and key findings

"Price improvement" in equities trading describes the process of getting a better-than-expected price when sending an order into the market. Price improvement occurs both on and off exchange, but regulatory constraints on exchange trading increments (or "tick size") limit the total benefit that many investors could receive. By reviewing data from the consolidated data feeds, we evaluate current price improvement behavior and quantify observed and potential investor benefits, finding:

- At common trade increments broadly available to all market participants, on exchange trading currently delivers 54% of total price improvement
- Just 12% of total price improvement occurs at sub-penny prices, as public investors are largely unable to compete at such price points[1]
- Harmonizing pricing rules across the market could yield **$6.3MM per day ($1.8B per year) in investor cost savings**, based on projected incremental savings if exchanges could offer sub-penny price improvement in a competitive manner[2]
- Tick increment changes would have an insignificant impact on market data message traffic



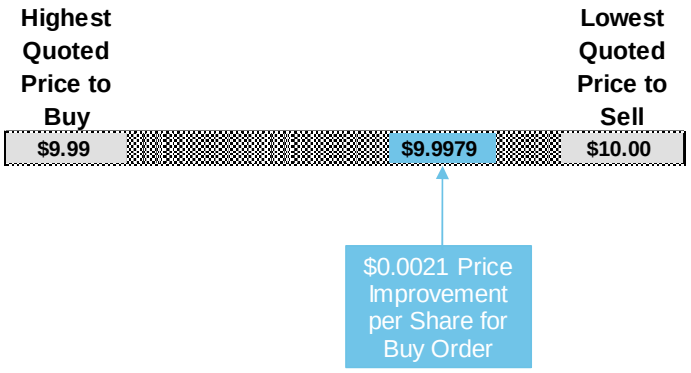


[1] Exchange retail programs like NYSE's "Retail Liquidity Program" operate with a limited exemption to Rule 612 that allows for 1/10th of a cent pricing increments for non-displayed retail-only liquidity. Because the resting RLP orders do not display their price or size, most retail order handling logic ignores their availability. As a result, exchanges only produce about $0.3MM in daily price improvement at sub-penny increments.

[2] Exchanges provide 1.17x as much price improvement as off-exchange (TRF) venues when combining round penny and midpoint trade prices; exchanges provide 77% as much price improvement as off-exchange trades when spreads are wider than $0.01. Applying the round penny+midpoint ratio to current off-exchange price improvement of $8.5MM, and adjusting for lower exchange benefit relative to spread, yields $7.3MM in potential additional trading cost savings from exchange trading. This is partially offset by $0.98MM in expected reduction in off-exchange price improvement from harmonized trade increments.

2. How is price improvement delivered today?

"Price improvement" (PI) in equities trading describes the process of getting a better-than-expected price when sending an order into the market. On exchange, price improvement is available when an incoming marketable[3] order interacts with resting non-displayed interest between the displayed quote, including midpoint orders, or displayed odd lot interest. With limited exceptions, exchange price improvement must occur in 1 cent increments or, in the case of a 1 cent wide bid-offer spread, ½ cent.[4] Most trading of marketable retail orders takes place off exchange. These off-exchange trades usually take place on a bilateral basis leveraging client segmentation capabilities, and market makers that trade with marketable retail orders are able to deliver a price in increments of up to 1/100 of a cent for stocks above $1.



We estimate current PI by aligning trade and quote data from the consolidated data feed (SIP).[5] We categorize trades as buys, sells, or midpoint based on the fill price relative to the National Best Bid and Offer (NBBO), with trades greater than (lesser than) the mid labeled as buys (sells). PI is measured as the difference between the execution price and National Best Offer for buys and the National Best Bid for sells; midpoint fills are measured as having PI equal to half the spread. We perform additional tests for market conditions and leverage execution reporting information from the SIP to distinguish between on and off exchange trading, with off exchange trading represented by any transactions reported by a Trade Reporting Facility ("TRF", a market mechanism for reporting trades conducted away from exchanges).

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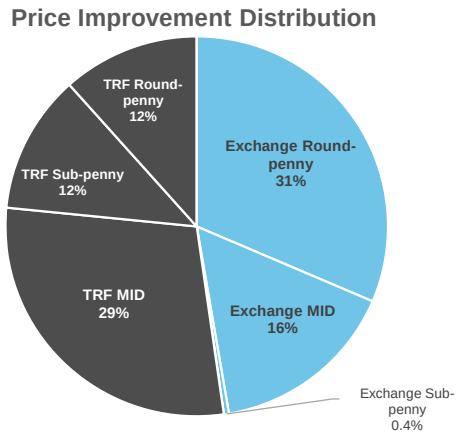
[3] "Marketable" refers to orders priced at or better than the opposite side of the market, meaning that these orders should be able to get an immediate execution based on price (but may not if there is not sufficient size). A buy order is considered marketable if it is priced equal to or above than the National Best Offer price. A sell order is considered marketable if it is priced equal to or below the National Best Bid price. Market orders are always considered marketable.

[4] The exceptions referenced here are the retail liquidity programs described above. There are various **limitations** to these programs, hence the small price improvement levels.

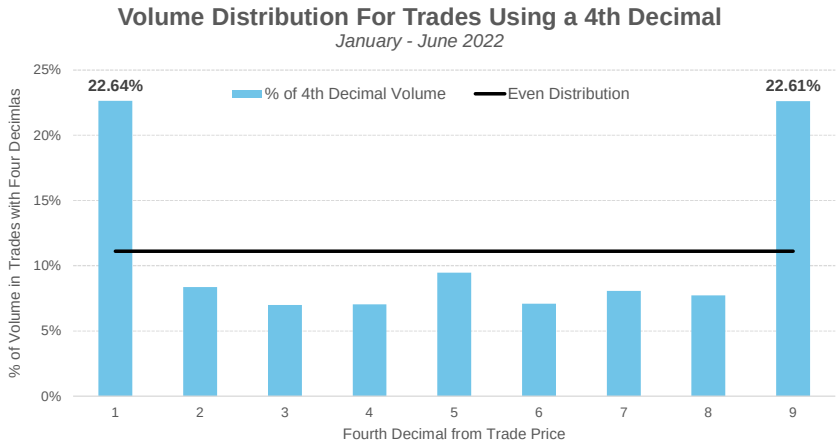
[5] In this analysis we exclude auctions, trades with sale conditions other than ISO and odd lot (such as extended hours, average price, and contingent trades), trades outside the NBBO, locked and crossed quote scenarios, and any activity below $1. Data covers Jan 1 - June 30 2022.

We find that aggregate PI amounts to approximately **$72MM per day**, relatively small (0.01%) compared to the $522bn daily trading interest analyzed.[6] 48% of this is delivered via exchange trading and 52% via off-exchange trading. Most PI is delivered via midpoint and round penny trades within the NBBO. Just 12.4% of PI comes from non-midpoint trades priced in tenths or hundredths of a cent; exchanges have very limited opportunity to trade at such price points.



Dollar Value Traded & Price Improvement Summary - 1H 2022					
			Price Improvement Distribution		
	Total Dollar Value Traded	Total Price Improvement	Round Penny	Midpoint	Sub-Penny
Exchange	$329,458	$34.3	$22.6	$11.4	$0.3
Off-Exchange	$192,478	$37.5	$8.3	$20.7	$8.5
Total	$521,936	$71.8	$30.9	$32.1	$8.8

Further examining trades priced at sub-penny increments reveals one factor for these trades' relatively small PI benefit. Use of the most granular pricing increment, 1/100 of a cent, often has a negligible economic impact on the trade price. 45.2% of all trades using a 4th decimal place have a 1 or 9 as the 4th decimal, suggesting little real impact from this pricing flexibility.



[6] For comparison we also measure total spread-crossing costs. We measure this as the difference between the execution price and the NBBO midpoint, meaning a midpoint trade would have 0 cost, a trade at the bid or offer would have a cost equal to half the spread, and trades receiving some PI would have a cost between 0 and half the spread. This totals approximately $103MM per day.

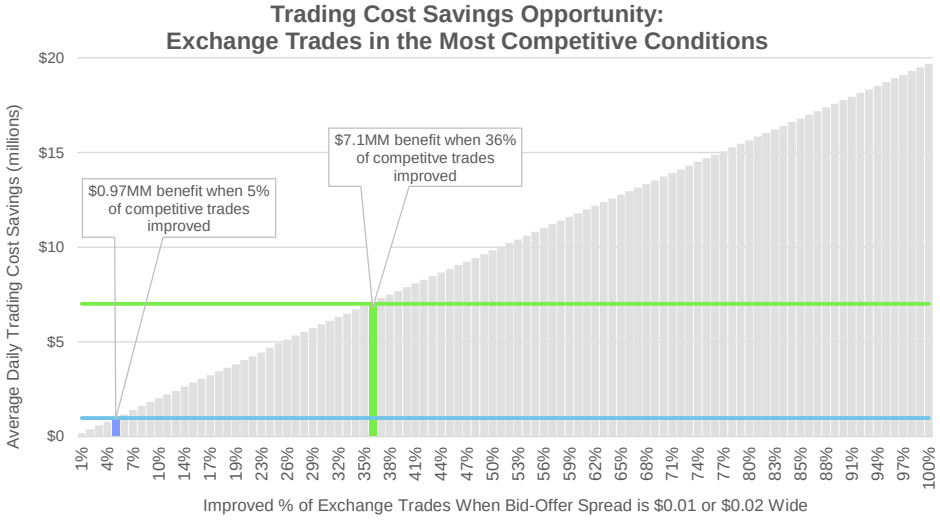
3. Trading Increment Harmonization

3.1. What would happen if the trade increment was harmonized at $0.0025?

One alternative under consideration for market structure reform is adjusting the trading increment to $0.0025 for both on and off-exchange trading. In practice, this would likely consist of establishing displayed quoting increments of half-penny increments and continuing to permit midpoint trading.[7]

To analyze such a change, we establish a scenario which assumes a minimum trade increment of ¼ of a cent ($0.0025). We next align all existing TRF trade reports to this new minimum increment, assuming that a different increment always results in worse trade prices from the perspective of the liquidity taker. This means trades estimated to be buys (sells) are rounded up (down) to the nearest ¼ cent.

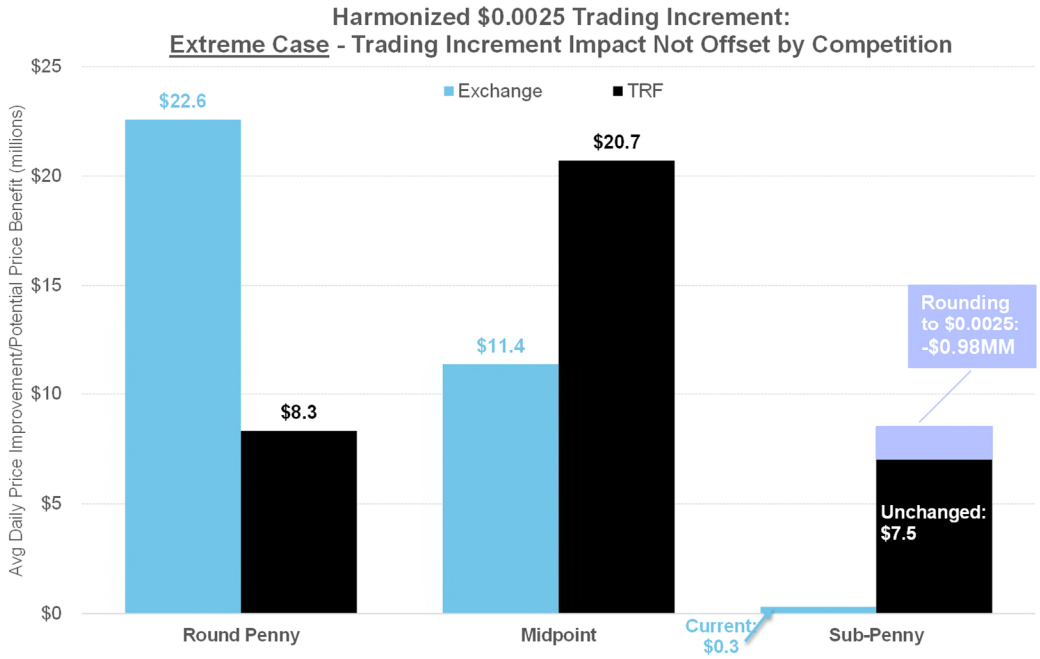
Further, with the ability to quote at finer increment, some existing exchange activity would occur at better prices for the liquidity taker, offsetting changes occurring off-exchange. To measure this benefit, we examine exchange trades at the bid and offer (i.e., trades not receiving any PI today) when the spread is $0.01 or $0.02 wide and improve the price on randomly-selected trades by $0.005. Applying this $0.005 PI to just 5% of these competitive trades results in $0.98MM in daily trading cost savings to marketable orders, offsetting the PI change described above. For exchanges to offer better pricing on these trades at rates equivalent to today's midpoint and round penny PI, exchanges need to provide $0.005 better prices 36% of the time.[8]



[7] Throughout this paper, "trade increment harmonization" refers to equal trade pricing rules for all on and off exchange trading, with exchanges able to display quotes at twice the trade pricing increment.
[8] These results assume $0.005 per share better prices on trades with spreads $0.01 or $0.02 wide at the time of execution. Should trade increment harmonization occur we would expect additional examples of

3.2. Extreme case estimate

Our base case scenario above assumes that a modest increase in exchange quoting competition offsets PI lost due to reduced trade price granularity. To create an extreme, worst-case impact estimate we maintain the assumption that a different increment results in worse trade prices from the perspective of the liquidity taker, but with no offsetting benefit from better exchange pricing. Such a scenario reduces aggregate market PI by just **1.4%**.



3.3. Competitive reaction impact

With the ability for public investors to tighten displayed quotes (and/or rest orders at narrower midpoint prices) via harmonized trade increments, it is fair to expect better results than the above scenarios indicate. We expect the reaction to such a major regime change will be some mix of favorable and unfavorable changes for marketable orders. For example, some buy orders will pay higher prices, but some will also pay lower prices as additional market participants can effectively use price points previously available only on bilateral trades.

To demonstrate, assume an investor seeks to buy a stock priced around $10.00. When looking at the market quotes, the investor sees the lowest quoted price to sell is $10.00. Today, the investor may receive price improvement from a market maker in increments as small as $0.0001,

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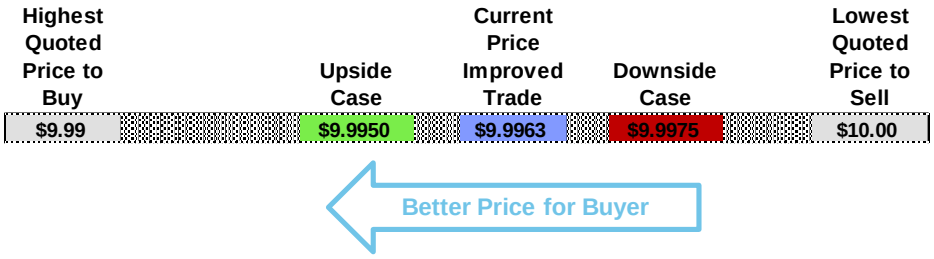
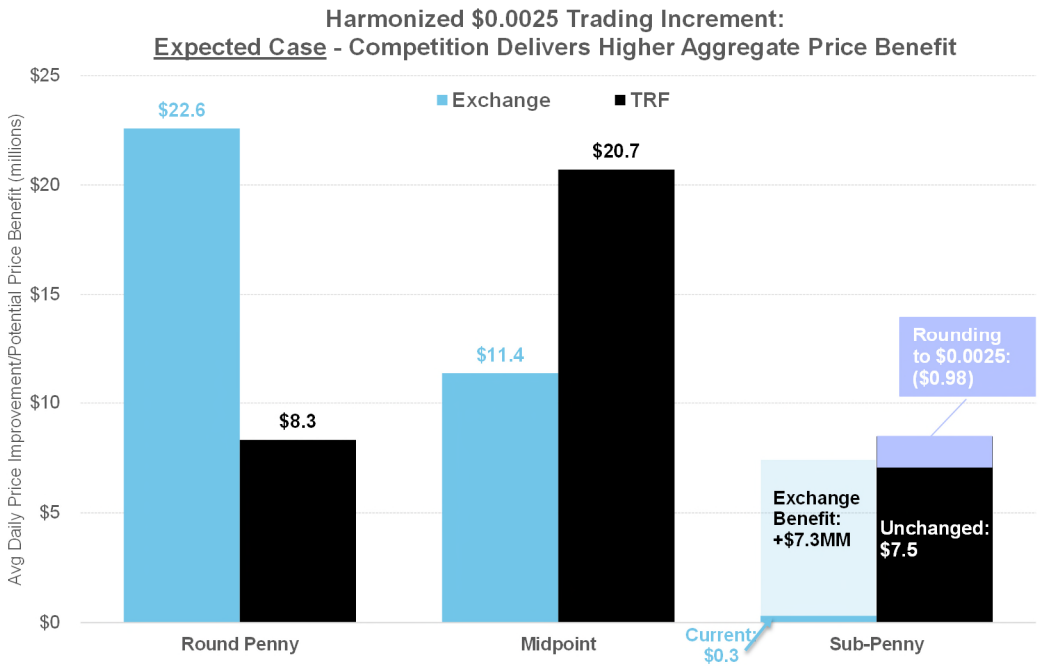
better pricing, such as midpoint ($0.0025) improvement on some trades and improvement on trades with wider spreads.

such as the $9.9963 price shown below. If trade increments were harmonized at $0.0025, a similar trade would be priced at either $9.995 or $9.9975.



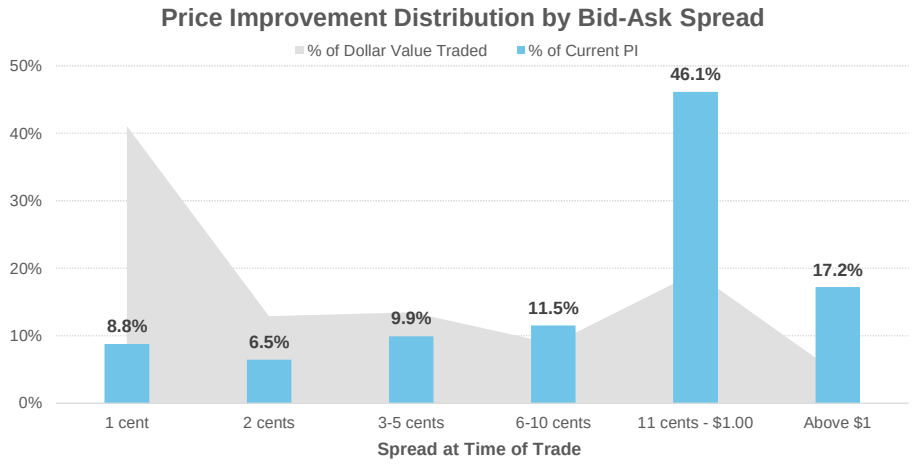
The exact mix of favorable and unfavorable changes will be determined by the market. Given the small impact in the extreme scenario shown in section 3.2, more competitive exchange quoting could easily replace or surpass forgone off-exchange PI. Exchanges currently provide 1.17x the amount of off-exchange PI at midpoint and round penny increments, where trading increment rules are more alike. At the same time exchanges also provide less PI when adjusting for the market spread (about 77% of the off-exchange amount). Applying these ratios to current off-exchange sub-penny PI yields an additional $7.3MM in daily price benefit, $6.3MM more than the base case.

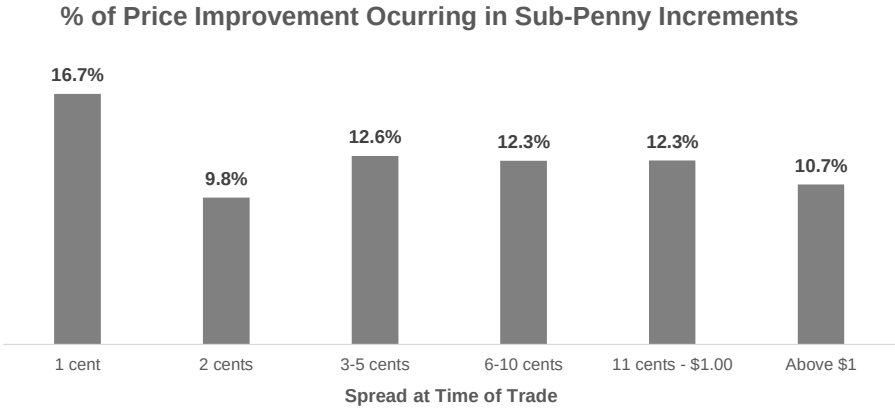


4. Market Conditions & PI

4.1. Spread

The smallest available quoting increment available on exchanges for the vast majority of stocks is $0.01.[9] In many cases, stocks with a $0.01 spread have liquidity **characteristics** suggesting the spread could be tighter than $0.01 if the rules allowed. As mentioned above, off-exchange market makers can execute trades in increments as small as $0.0001. Somewhat surprisingly, this ability is not used frequently in trades with a $0.01 spread, where the trade increment difference between on and off exchange venues is most pronounced. We find that most PI, sub-penny or not, is delivered via trades where the bid-offer spread is larger than $0.10. This indicates opportunity to provide better prices exists across various spread conditions, and suggests that further competition from trade increment harmonization could produce greater price benefit to marketable orders across stocks.

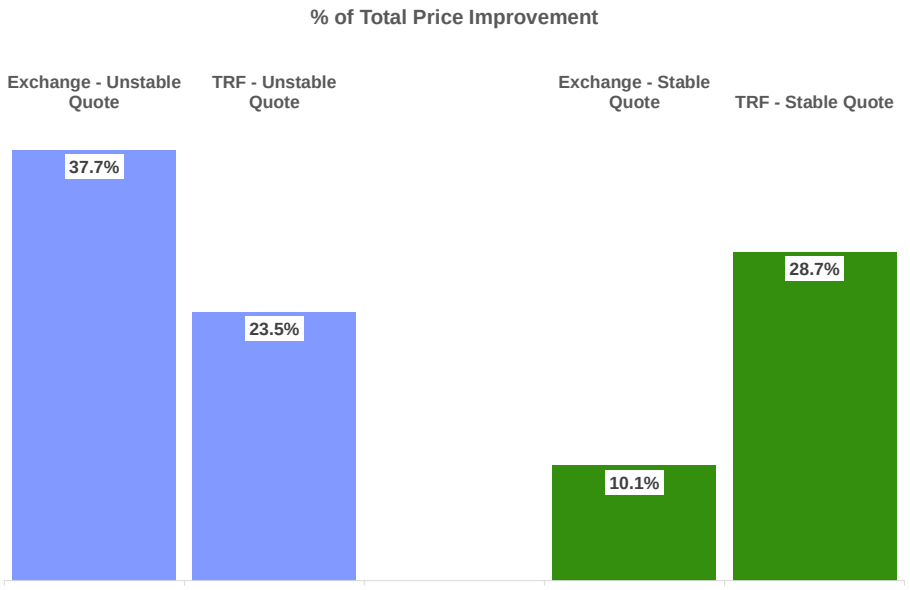




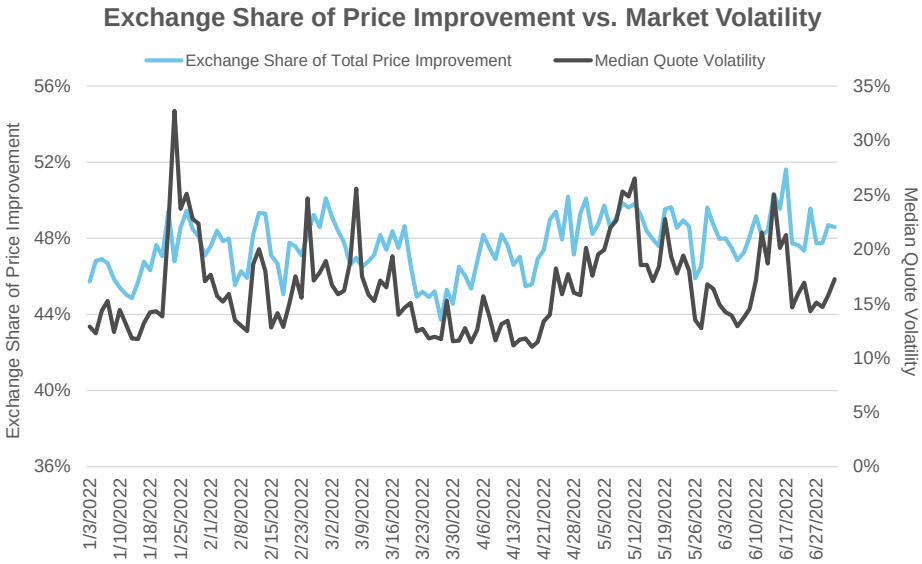
[9] For stocks priced at least $1. The quoting increment for stocks priced under $1 is $0.0001.

4.2. Volatility

We also find that market volatility plays a role in PI. To examine market conditions around the time of the trade, we consider a "calm" market when there is a stable quoted market price for a restrictive 100 milliseconds before and after the trade. Adding this condition shows more TRF PI during calm markets than volatile markets, implying that during calm markets, orders are more likely to trade on an off-exchange venue.



These observations are consistent with higher-level trends in volatility and off-exchange trading. We compare daily PI amounts with Quote Volatility,[10] a measure of short-term price movement, on a daily basis. Exchanges tend to provide a higher share of total PI when volatility is higher; when volatility drops off-exchange venues increase their share of total PI. Through this lens we see the same pattern of off-exchange PI increasing in calm markets and falling in difficult markets.



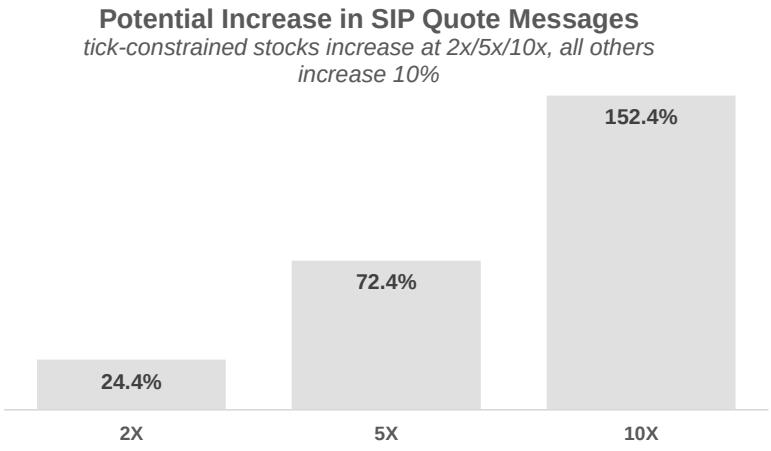
[10] See https://www.nyse.com/data-insights/introducing-quote-volatility-qv-a-new-metric-to-measure-price-volatility for more information.

5. Market Infrastructure Impacts

At the time of Reg NMS' adoption, there was concern that sub-penny quoting might overburden market infrastructure. Fifteen years later, the increase in messaging activity from adopting finer tick increments is now well within the industry's capability.

Any change in allowable quote and trade increments will have some impact on market data activity levels. Given that there is no relevant data today to hint at what changes may occur if stocks priced higher than $1.00 have a narrower quoting increment, we look to analogous situations to estimate potential impacts. For example, we can look at how quoting changes when stocks trade around $1 by examining individual stocks that traded both above and below $1 at some point during H1 2022[11]. For these stocks that trade both above and below $1, we see that SIP quoting activity roughly doubles when the price of the stock is below $1 (i.e. when it can be quoted in $0.0001 increments instead of $0.01 increments).

5.1. Estimating messaging changes



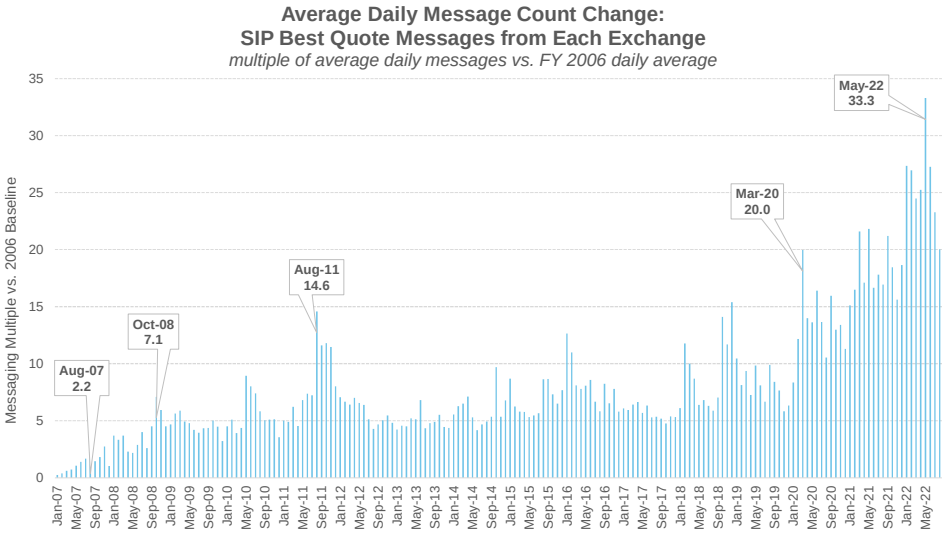
Reviewing data based on the sub-dollar priced stocks that can currently quote out to 1/100 of a cent overstates the impact of the trade increment harmonization discussed above, but that should be partially offset by the broader range of market participants trading in stocks above $1. There is a range of possible behavior change from any tick size regime change, so we estimate message traffic changes at various quoting multiples. We count all intra-day quotes submitted to the SIP by each exchange in tick-constrained stocks[12], and then assume message traffic increases of 2, 5, and 10 times current rates. We also increase message counts in unconstrained stocks by 10% to account for potential increased quoting activity in the rest of the market. This increases the count of best exchange quotes by between 24% to 152%,[13] leading to small changes in messaging levels relative to historical fluctuations

[11] We include all stocks that traded at prices both above and below $1 during H1 2022, traded at least 100,000 total shares, trading within a range of $0.25-$3.00, and excluded warrants.
[12] See **our study on tick constraints**, also referenced above
[13] We apply the 2x, 5x and 10x increases to stocks identified as tick-constrained in each of the last 6 6-month periods, and the 10% increase to all other stocks in each period. The aggregate increase across all periods examined was 24.4% when increasing tick-constrained stocks 2x, 72.4% when increasing tick-constrained stocks 5x, and 152.4% when increasing tick-constrained stocks 10x. This analysis also excludes any related or unrelated changes to market structure, such as the number of exchanges with protected quotes and round lot definitions

and overall messaging rates that remain quite modest compared to the data volumes prevalent in current-day options trading.

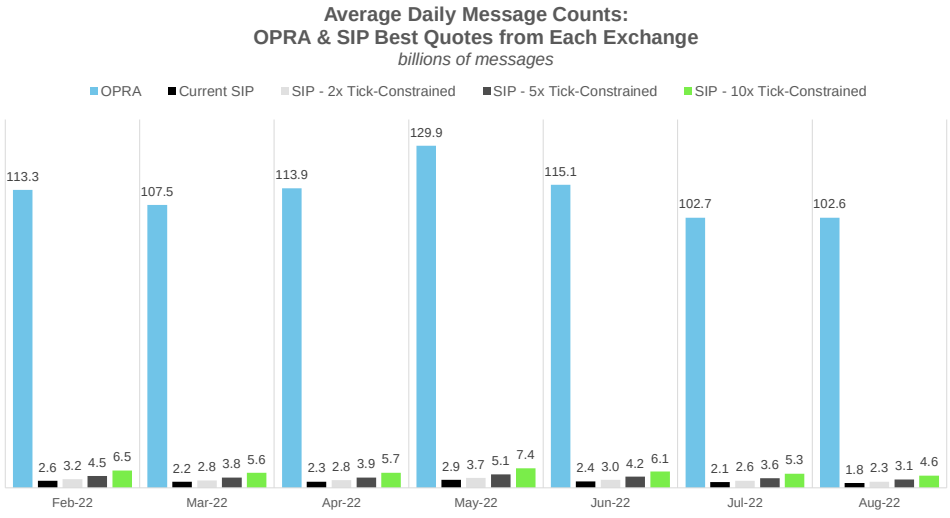
5.2. Message rate changes over time

US equity markets have experienced regulatory and technology changes and market fluctuations over the last 15 years which far outpace the potential messaging impacts described above. Benchmarking SIP quoting activity to 2006, before Reg NMS, finds that monthly average quote message activity had doubled by August 2007. Other market events such as the global financial crisis and the US credit downgrade caused further jumps in traffic. More recently, the pandemic and subsequent elevated market activity caused large variations in month-to-month rates, often well exceeding changes likely to arise from narrowing quoting increments.



5.3. Message traffic would remain tiny compared to other markets

The US listed options market trades about twice as many contracts per day in 2022 as it did prior to the pandemic. Given this increased activity and the huge number of individual options listings, OPRA (the SIP equivalent for the options market) handles many times more messages than the equity market. Applying the various quote message increase assumptions describe above to recent trading activity, we find that even with the largest potential increases the cash equity messaging activity would remain well below that of the options market.



6. Why This Matters

The recent focus on retail order execution has led to calls for a variety of market structure changes, some more onerous and intrusive than others. Harmonizing trading increments across the market can be a relatively simple change that will encourage competition in quoted prices and allow exchanges to offer better trade pricing in situations where public investors cannot compete today. As shown above, trade increment harmonization could result in a material enhancement to the price improvement benefits that marketable order flow receives today.