

March 30, 2023

By Electronic Submission

Ms. Vanessa Countryman
Secretary
U.S. Securities and Exchange Commission
100 F Street, N.E.
Washington DC 20549

**Re: File No. S7-30-22; Release No. 34-96494; Regulation NMS: Minimum Pricing
Increments, Access Fees, and Transparency of Better Priced Orders**

Dear Ms. Countryman,

We submit this letter on behalf of The MITRE Corporation (“MITRE”) in response to this equity market structure proposal, which was a focus of the Securities and Exchange Commission (the “Commission”) Open Meeting on December 14, 2022. With MITRE’s mission to solve problems for a safer world, we applaud the commitment by market regulators and participants alike to ensuring that the U.S. equities market remains the most liquid, efficient, and competitive in the world. This commitment strengthens the U.S. economy and secures the future for all Americans and our allies.

MITRE was one of the first in the scientific community to measure market inefficiencies at the scale now being identified by the Commission. Below, we provide a short list of recommendations informed by MITRE’s related research. In closing, MITRE welcomes the opportunity to partner both with the Commission and market participants to explore and implement these recommendations as well as those we identify collaboratively.

Respectfully,

/s/ Kevin B. Toner
Managing Director
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About MITRE

MITRE is a not-for-profit company that works in the public interest to tackle difficult problems that challenge the safety, stability, security, and well-being of our nation. We operate multiple federally funded research and development centers (FFRDCs); participate in and lead public-private partnerships across national security and civilian agency missions; and maintain an independent technology research program in areas such as artificial intelligence, intuitive data science, quantum information science, health informatics, policy and economic expertise, trustworthy autonomy, cyber threat sharing, and cyber resilience. MITRE's 10,000-plus employees work in the public interest to solve problems for a safer world, with scientific integrity being fundamental to our existence. We are prohibited from lobbying, do not develop nor sell products, have no owners or shareholders, and do not compete with industry. Our multidisciplinary teams (including engineers, scientists, data analysts, organizational change specialists, policy professionals, and more) are thus free to dig into problems from all angles, with no political or commercial pressures to influence our decision making, technical findings, or policy recommendations.

Over the past several years, MITRE has provided unbiased, trusted advice to multiple federal agencies and U.S. policymakers who seek to better understand rapidly changing technology developments across the full spectrum of capital markets. We have developed partnerships on key topics with industry, academia, and the nonprofit sector to understand, research, and develop capabilities—for example, the development of NMS-scale models and analytics. MITRE has demonstrated its capacity as a convener by bringing together the industry, government, and nonprofit sectors to share insights and deepen a collective understanding of policy goals, challenges, and the current state of technology developments in order to gain a more holistic view of how the government and industry should tackle the many challenges in the capital markets ecosystem. Specifically, over the past two years, MITRE hosted prominent regulatory, industry, and academic stakeholders for a technical exchange focused on “Ensuring U.S. Leadership in Digital Assets,” facilitated discussions between federal regulators and national security professionals identify synergistic missions securing the U.S. financial system, and contributed technical expertise to a number of government-hosted exchanges focused on global resiliency and competitiveness.

Introduction

On December 14, 2022, the Commission held an open meeting to consider a full agenda, including four rule proposals to revisit equity market structure. Regulation National Market System (“RegNMS”) serves a central role amongst all regulatory rules. Therefore, we focus our attention here on proposed changes to RegNMS.

With many facets to the proposed changes to RegNMS, we provide here only a brief summary of RegNMS and the proposed changes to it. In general, RegNMS ensures that investors receive executions of their orders according to the National Best Bid and Offer (“NBBO”). We

note that Chair Gensler recently referred to the NBBO as a “faulty measuring rod”¹ to assess the quality of order execution. To address some of the current limitations with the NBBO, the Commission proposes several changes to RegNMS, to include:

- Reduction of market access fees
- Reduction of the minimum price increment for quoting (*i.e.*, tick size)
- Reduction of the minimum price increment for retail trading
- Modifications to the display of best quotes (*i.e.*, odd lots).

In totality, this set of proposed changes to RegNMS represents substantive changes which may have sweeping impacts on the National Market System. Prominent market participants have previously highlighted the absence of market simulations to conduct comprehensive experiments prior to the implementation of major policy changes.²

We note that Nasdaq previously commissioned the development of a market simulation to anticipate market dynamics when regulatory attention previously focused on altering minimal tick sizes.³ Drawing upon the success of those early simulations, MITRE has undertaken a research program to design and develop the next generation of market simulations.⁴ While we continue to apply these simulations to conduct experiments of various tick sizes and their impacts on market dynamics, MITRE would welcome the opportunity to review these and related studies with Commission leadership.

Center for Financial Innovation

Moving forward via these experiments presents opportunities and challenges. The U.S. financial system is both dynamic and complex; and filled with regulatory and competitive relationships. As part of its mission to perform science in the public interest, MITRE created the

¹ Problem with John Stewart, “SEC Chair Gary Gensler Answers Your Questions,” October 12, 2022. <https://www.youtube.com/watch?v=7aTD9Ybv2E>.

² Cunningham, S. “We’re Suing the SEC to Protect the Stock Market,” *Wall Street Journal*, 15 Feb 2019.

³ Darley, V., et al. “Learning, evolution and tick size effects in a simulation of the NASDAQ stock market.” *Proceedings of the 5th World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando, Florida*. Vol. 6. 2001.

Darley, Vincent. *A NASDAQ market simulation: insights on a major market from the science of complex adaptive systems*. Volume 1. World Scientific, 2007.

⁴ Tivnan, B., et al. “Adding to the regulator’s toolbox: Integration and extension of two leading market models.” *arXiv preprint arXiv:1105.5439* (2011).

Johnson, N., et al. “Abrupt rise of new machine ecology beyond human response time.” *Scientific reports* 3.1 (2013): 2627.

Bookstaber, R., M. Foley, and B. Tivnan. “Toward an understanding of market resilience: market liquidity and heterogeneity in the investor decision cycle.” *Journal of Economic Interaction and Coordination* 11 (2016): 205-227.

Tivnan, B., et al. “Towards a model of the US stock market: How important is the securities information processor?” *2017 Winter Simulation Conference (WSC)*. IEEE, 2017.

Van Oort, C., B. Tivnan, and S. Wshah. “Adaptive Agents and Data Quality in Agent-Based Market Models.” *In Preparation*.

Center for Financial Innovation (“CFIN”). Our vision for CFIN is to be an objective, science-based center for the analysis of the financial system. The National Market System serves as a cornerstone of the CFIN research program.

Leveraging MITRE’s long history of objective analyses and data safeguarding, members of CFIN (*e.g.*, public and private companies, regulators, and academic institutions) will be able to share data, perform analyses, direct studies, and shape experiments in a secure, noncompetitive forum to inform regulation and business practice. MITRE has established and led similar consortia in other industries, such as the aviation industry (www.asias.faa.gov), the ground transportation industry (<https://www.nhtsa.gov/parts-partnership-for-analytics-research-in-traffic-safety>) and cybersecurity in the private sector (<https://mitre-ingenuity.org/cybersecurity/attack-evaluations/>).

Moreover, MITRE is well suited to serve in this role as the central hub of CFIN. The Federal government has leveraged MITRE’s science and engineering expertise for more than 60 years. MITRE maintains a non-profit status and an independence from both the Federal government (*e.g.*, MITRE is not a regulator, not subject to the Freedom of Information Act, nor subject to the Federal Advisory Committee Act) and the population of market participants. For more information about CFIN, please contact us at: cfin@mitre.org.

Overarching Recommendations

MITRE encourages the Commission to consider several details that could impact the implementation of the proposed rule. More specifically, we believe that additional thought should be devoted to the definition (and method of identification) of tick constrained stocks, the use of larger tick sizes, careful scheduling of tick size updates, a data driven approach to determining the appropriate tick size update frequency and Time Weighted Average Spread (“TWAS”) evaluation period duration, edge effects in the dynamic tick size update mechanism, and additional quantitative methods for understanding the direct and indirect effects of proposed regulation.

Some market participants have expressed concerns over the broad scope of the recent market microstructure rule proposals, and others have raised concerns about the positive identification of tick constrained symbols. The methodology selected by the Commission identified 1337 symbols as being tick constrained, while the methodologies employed by several market participants identify smaller groups of symbols. MEMX identified roughly 1000⁵, Nasdaq identified 570⁶, and CBOE identified 920 (or even less under additional criteria)⁷. Using a narrower identification methodology could reduce implementation costs, reduce the chance of identification error, and reduce potential volatility effects driven by market participants adapting

⁵ See “The Tick Size Debate, Revisited”, (January 2022), available at <https://memx.com/market-structure-report-the-tick-size-debate-revisited>.

⁶ See “The Tick-Constrained Stock Problem”, (January 20, 2022), available at <https://www.nasdaq.com/articles/the-tick-constrained-stock-problem>.

⁷ See “CBOE Proposes Tick-Reduction Framework to Ensure Market Structure Benefits All Investors”, (September 22, 2022), available at <https://www.cboe.com/insights/posts/cboe-proposes-tick-reduction-framework-to-ensure-market-structure-benefits-all-investors/>. Also see “An Update to our Tick Reform Proposal”, (March 6, 2023), available at <https://www.cboe.com/insights/posts/an-update-to-our-tick-reform-proposal/>.

to market microstructure changes.

Recent theoretical⁸ and quantitative⁹ studies have provided supporting evidence that affirms the Commission's decisions regarding smaller tick sizes for stocks with narrow spreads, but also supports the use of larger tick sizes for stocks with wider spreads. For stocks with large enough spreads the mechanical increase in spread due to the larger tick size should be of negligible economic significance, while depth aggregation and reduced under cutting should improve liquidity provision.

In addition to these tuning details, we believe that special care should be exercised in designing the update schedule in the dynamic tick size regime. The Commission should avoid dynamic tick size updates on trading days that are known to exhibit excess volatility. For example, the first and last days of the year, quarter, month, and week have been identified as having characteristically higher volatility than the typical trading day. Other similar concerns include fundamental information events (FOMC meetings, earnings calls, CPI releases, etc.) and options expiry days. Updating the tick size during one of these market events may exacerbate already elevated volatility and damage investor confidence in US markets.

Related to this, the Commission has requested comments on the appropriate evaluation interval and update frequency. We advocate for a data driven approach and encourage the Commission to investigate historical rates of change in the TWAS for a variety of trading symbols. This would avoid imposing undue costs on market participants that may be caused by tick size updates that are too frequent but should mitigate the possibility that tick sizes do not update frequently enough and lead to worse trading outcomes.

Next, the Commission should consider the possibility of tick size oscillations for some stocks that fall close to the threshold values for TWAS. It is possible that a stock that has recently crossed a TWAS threshold, leading to a reduced tick size following the next evaluation period, would suffer from increased undercutting and may then revert to a larger tick size in the following evaluation period. This tick size oscillation will impose excessive costs on market participants that could be mitigated using additional criteria, momentum effects, etc.

Finally, we encourage the Commission to consider additional quantitative methods for understanding the direct and indirect effects of proposed regulations. In particular, we believe that a simulation-driven experiment can be an effective tool for understanding a variety of emergent phenomena that are difficult to assess using many traditional methods. Previously the Commission has executed a variety of pilot programs in order to collect data from live markets to inform market design and regulation. However, recent pilot programs have faced resistance from market participants.¹⁰ Simulation-driven experiments can fulfill a similar role, allowing the

⁸ See "Discrete Price, Discrete Quantity, and the Optimal Price of a Stock", (December 9, 2022), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3763516. Also "When Does the Tick Size Help or Harm Market Quality? Evidence from the Tick Size Pilot". Also "Optimal Tick Size", (March 2, 2023), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4341374. Also "When bigger is better: The impact of a tiny tick size on undercutting behavior", (June 26, 2020), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3194932.

⁹ See "Revisiting the Tick Size Pilot", (November 28, 2022), available at https://www.sec.gov/files/dera_wp_ticksize-pilot-revisit.pdf.

¹⁰ See "Appeals Court Rules for Stock Exchanges in Fee Fight With SEC," (June 16, 2020), available at <https://www.wsj.com/articles/appeals-court-rules-for-stock-exchanges-in-fee-fight-with-sec-11592322391>

Commission to continue a data-driven approach to developing market regulation, yet in a more controlled environment and absent any risk to the market itself.

As a proof-of-concept, we used a MITRE-developed model⁴ of the NMS to investigate the impacts of exogenous, tick size changes on a pair of fictitious stocks. Our model features exchanges running continuous double auctions, communication infrastructure with propagation delays, and an assortment of simple trading agents (*i.e.*, Zero Intelligence (ZI)¹¹, Zero Intelligence Plus (ZIP)¹², and arbitrageurs). Our experimental design revolves around tick sizes of \$0.05, \$0.01, \$0.005, and \$0.001. To estimate some impacts of trader behavior, we also consider two trader populations, one composed primarily of ZI traders along with an arbitrageur and the second composed primarily of ZIP traders along with an arbitrageur.

Our experiment featured more than 100 trials with an average of 476,000 trades and 62.5 million shares of volume. In all trials, both trading symbols started with a share price randomly distributed about \$100.00, with completely endogenous price dynamics for the remainder of the trial. The conditions featuring ZI traders experienced wider spreads, ~\$1.14 on average, while the ZIP traders with their more informed price beliefs engendered narrower spreads, ~\$0.35. TWAS differences between ZIP and ZI conditions were almost all statistically significant at the 0.05 level under a two-sided t-test. Comparisons between conditions with varying tick sizes with the same agent populations were less conclusive. Amongst the ZI trials, only \$0.01 vs \$0.001 was significant (mean of \$1.1566 vs \$1.135, p value = 0.0421). Amongst the ZIP trials, only \$0.005 vs \$0.001 was significant (mean of \$0.3704 vs \$0.3431, p-value = 0.0155). These results indicate that the mechanical effects of tick size changes on non-tick constrained stocks are relatively small compared to the effects of trader behaviors and interactions.

The above results highlight the power of simulation to inform the rulemaking process. Yet, we note the preliminary nature of these results and briefly describe some of the current limitations of this experiment. We underscore the lack of tick-constrained stocks, trading strategies that are heavily influenced by tick-size changes, and strategic trading adaptation in the face of tick-size changes. Given more time for a comprehensive analysis, we expect that a thoughtful investigation of tick-constrained stocks, additional trading strategies and calibration could be accomplished with a modest level of effort, while strategic adaptation to microstructure changes might require additional research.

In closing, MITRE encourages the Commission to embrace market simulations to inform the design, development, and implementation of market reforms. In pursuit of this, MITRE invites the Commission to engage with CFIN to include market simulations in the rulemaking process.

¹¹ See "Allocative Efficiency of Market with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality", (February, 1993), available at <https://www.journals.uchicago.edu/doi/abs/10.1086/261868>.

¹² See "Zero is Not Enough: On the Lower Limit of Agent Intelligence For Continuous Double Auction Markets", (November, 1997), available at <http://shiftright.com/mirrors/www.hpl.hp.com/techreports/97/HPL-97-141.pdf>.