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HIGH-FREQUENCY TRADING IN NANOSECONDS: ANALYSIS, MODELING, AND POLICY IMPLICATIONS

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EXECUTIVE SUMMARY

This interdisciplinary project involves economics and computer science and examines how to analyze and understand financial trading and its effects on the stock market. It fosters research on the financial ecosystem by hosting a series of collaborative workshops with financial economists and data scientists. The goal is to create new metrics and data for the discipline of finance in economics and inform public policy in the era of big data.

RESEARCH CHALLENGE

The advent of big data has reshaped not only the methodological challenges and opportunities facing financial economics but also the phenomena studied in the field. However, traditional academic research in finance emphasizes economic explanations to such an extent that, in the words of the prominent economist Susan Athey, "If you said that an economist was data mining, that was an insult." Consequently, big data techniques have as yet gained little traction in academic research.

Existing studies in financial economics focus mostly on the economic behavior of humans. Advances in computing technology and machine-learning techniques have introduced cyber players, which use computer algorithms to make trading decisions. Existing U.S. Security and Exchange Commission (SEC) regulations, however, are designed for human traders. This project lays the groundwork for public policy for cyber traders in the era of big data. The research aims to understand the origin and impact of these cyber players in financial markets. The focus is on high-frequency traders (HFTs), which are cyber players that operate at exceptional speed, measurable in nanoseconds.

METHODS & CODES

The NASDAQ exchange provided more than 15 TB of raw data consisting of 10 years of records consisting of all the orders submitted, executed, and canceled in the NASDAQ market during that time period. The team combined all of these messages and generated snapshots of the market at the resolution of nanoseconds using the computational power of Blue Waters. The financial data could easily be sliced to the granularity of stock-days, and the biggest stock-day (May 6, 2010, or the so-called flash crash day) is only a matter of hundreds of MB.

To balance the CPU loading, the researchers distributed larger jobs to CPUs first and then filled in smaller jobs when larger jobs were completed. Aggregation of outputs was easy and could be done with a single node.

RESULTS & IMPACT

The research team discovered an important driver of high-frequency trading: discrete prices. The SEC's Rule 612 imposes a minimum price variation for stock trading called a tick size. The prevailing one-cent tick size constrains price competition. The first-come, first-served rule at the same price then generates queuing, or early arrival to the market, to beat rivals.

Yao and Ye [1] found that HFTs are more active in securities with lower prices because a one-cent uniform tick size implies a larger relative tick size. Further, they showed that the current policy initiative to reduce HFTs by increasing the tick size would only encourage HFTs. Li, Wang, and Ye [2] incorporated a discrete tick size and allowed non-high-frequency traders (non-HFTs) to supply liquidity.

The findings show discrete pricing leads to higher transaction costs for non-HFTs. The Li, Ye, and Zheng [3] and Ye, Zheng, and Zhu [4] studies investigate the real effects of the secondary market. The SEC implemented a tick size pilot program from 2016 to 2018 to increase tick size from 1 cent to 5 cents for 1,200 randomly selected stocks. The Li, Ye, and Zheng [3] findings show that the increase in tick size reduces stock market liquidity and that firms that face tick-size constraints reduce their share repurchase by 45%. Further, the Ye, Zheng, and Zhu [4] findings show that after the tick size pilot, treated firms' investment-q sensitivity increases, resulting from an increase in stock price informativeness and managers incorporating the information from the stock price into investment decisions.

This project has stimulated collaborations among financial economists, computer scientists, and experts on high-performance computing (HPC). The PI has organized three conferences in collaboration with the National Bureau of Economic Research, the National Center for Supercomputing Applications (NCSA), and top finance journals to jump-start big data research in finance. NCSA Director William Gropp and several experts on supercomputing from XSEDE (https://www.xsede.org) gave lectures during the conferences. SEC Chief Economist S. P. Kothari spoke about policy challenges and research opportunities in the era of big data (https://bit.ly/31iIKK1). The co-editor of *The Journal of Financial Economics*, Toni Whited, gave a speech about HPC for structural estimation. The PI spoke about big data in finance. A website has been created for the collaborative workshops, including videos of the two keynotes (https://bit.ly/2MhL0gj). The PI will organize five more collaborative conferences in the future.

WHY BLUE WATERS

The research team is the first academic research group to use the power of supercomputing to analyze the financial market. Because Blue Waters and NCSA are located in Champaign–Urbana, it was easier for the researchers to access staff support. The research team also benefitted from attending the Blue Waters Symposium (https://bluewaters.ncsa.illinois.edu/blue-waters-symposium-2019). In addition, the file transfer is faster to/from Blue Waters than any remote sites, which is a unique advantage of using Blue Waters.