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Contents lists available at ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/jfecHigh frequency market microstructure[☆]Maureen O'Hara^{*}

Johnson Graduate School of Management, Sage Hall Cornell University, Ithaca, NY 14853, USA

ARTICLE INFO

Article history:

Received 26 March 2014

Received in revised form

1 August 2014

Accepted 26 August 2014

Available online 29 January 2015

JEL classification:

D02

D83

G14

Keywords:

High frequency trading

Market microstructure

Algorithmic trading

ABSTRACT

Markets are different now, transformed by technology and high frequency trading. In this paper, I investigate the implications of these changes for high frequency market microstructure (HFT). I describe the new high frequency world, with a particular focus on how HFT affects the strategies of traders and markets. I discuss some of the gaps that arise when thinking about microstructure research issues in the high frequency world. I suggest that, like everything else in the markets, research must also change to reflect the new realities of the high frequency world. I propose some topics for this new research agenda in high frequency market microstructure.

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1. Introduction

Markets are different now in fundamental ways. High frequency trading (HFT) has clearly made things faster, but viewing the advent of HFT as being only about speed misses the revolution that has happened in markets. From the way traders trade, to the way markets are structured, to the way liquidity and price discovery arise – all are now different in the high frequency world. What is particularly intriguing is the role played by microstructure. One could expect that when things are fast the market structure

becomes irrelevant, but the opposite is the case. At very fast speeds, microstructure takes on a starring role.

To understand this evolution of the market from human involvement to computer control, from operating in time frames of minutes to time scales of microseconds, it is important to recognize the role played by strategic behavior. High frequency trading is strategic because it maximizes against market design, other high frequency traders, and other traders. HFT strategies can be quite complex, but so, too, are the strategies that other traders elect, in part because they need to optimize in a market that contains HFT players. And the exchanges act strategically as well, opting for new pricing models and market designs to attract (and, in some cases, deter) particular volume to their trading venues. As a result, trading has changed, and the data that emerge from the trading process are consequently altered.

In this paper, I investigate the implications of these changes for high frequency market microstructure. My goal is not to explain high frequency trading per se, but rather to set out some important aspects of this high frequency transformation. For finance researchers more

[☆] My thanks to Bill Schwert and Ken French for suggesting this paper to me. I am very grateful to two referees, Ayan Bhattacharya, David Easley, Frank Hatheway, Joel Hasbrouck, David Meitz, Pam Moulton, Gideon Saar, and Mao Ye for help and guidance with this paper. I particularly wish to thank Jamie Selway, Jeff Bacidore, Wenjie Xu, Cindy Yang, and Lin Jiang for all of their help with this project. Maureen O'Hara is chairman of the board of directors of Investment Technology Group (ITG), a global broker-dealer firm focusing on the needs of buy-side institutional clients.

^{*} Tel.: +1 607 255 3645; fax: +1 607 254 4590.

E-mail address: mo19@cornell.edu

generally, understanding how markets and trading have changed is important for informing future research. For microstructure researchers, I believe these changes call for a new research agenda, one that recognizes how the learning models used in the past are lacking and why traditionally employed empirical methods might no longer be appropriate. Equally important, microstructure research must provide more policy guidance, reflecting the problem that the new complexity of markets can confound even the best-intentioned regulators.

Some of this agenda for high frequency market microstructure research is well under-way, with a large and vibrant literature developing on high frequency trading. In this paper, I highlight some of these new directions but stop far short of surveying the high frequency trading literature (more extensive reviews are [Biais and Wooley, 2011](#); [Jones, 2012](#); [Goldstein, Kumar, and Graves, 2014](#)). Instead, my hope is to demonstrate how markets have changed, illustrate the new range of issues confronting researchers, and suggest some fundamental questions I believe need to be addressed in microstructure research.

This paper is organized as follows. [Section 2](#) describes the high frequency world, with a particular focus on how HFT affects the strategies of traders and markets. I set out some basics of the present market structure and discuss the role regulatory change played in setting the stage for high frequency trading. I consider the behaviors and strategies of high frequency and non-high frequency traders, and I examine how HFT has affected the organization of trading, giving particular attention to exchange pricing models, order priority rules, and the development of new trading platforms. [Section 3](#) discusses gaps that arise when thinking about microstructure research issues in the high frequency world and proposes some topics for this new research agenda in high frequency market microstructure. [Section 4](#) identifies some of the complex regulatory and policy issues needing further study in high frequency markets.

2. The high frequency world

Over the last decade, the forces of technology, speed, and computer-based trading have increasingly shaped the structure and behavior of markets. While much has been made of the activities of high frequency traders, the behavior of non high frequency traders is also now radically different and so, too, are the markets in which this trading occurs. In this section, I describe this new high frequency world, with the goal of conveying at least partially the sea change that has transformed trading.

2.1. The setting

The technology that allowed for high frequency trading was developing over the 1990s, but it was regulatory policy changes intended to increase competition that ushered in the high frequency era. In the U.S., Regulation ATS (alternative trading systems; Reg ATS) in 2000 allowed for the entry of a variety of non-exchange competitors, while Regulation National Market System (Reg NMS) in 2007 set out a vision of a market composed of

multiple trading venues all linked together via rules over access and trade priority. In Europe, MiFiD in 2007 had a similar effect in allowing new competition and trading venues. As a consequence, equity markets in the U.S. and Europe fragmented, with trading dispersed across a variety of exchanges and markets.

The U.S., there are 11 equity exchanges, and 50 or more alternative trading systems (these include crossing networks and dark pools operated by broker-dealer firms) executing trades for customer orders. There are also dozens of trading desks executing trades internally at firms such as Goldman Sachs, Credit Suisse, Citibank, and the like. Added to this are 13 US options exchanges trading equity derivatives, as well as several futures markets trading relevant equity-linked contracts.

Fragmentation introduces a variety of complexities into the trading environment. Without a central market, traders need to search for liquidity across many venues and the ability to do so at high speeds is valuable. Multiple venues executing trades also means that prices need not always be the same, opening the door for arbitrage across markets. Advances in technology allowed this to happen but so, too, did decisions by exchanges to allow (for a fee) some traders to trade faster by co-locating their trading systems at the exchange site. The exchanges also offered (for a fee) direct feeds of their trading information, giving high speed traders an ability to see the market with more clarity than traders receiving standard consolidated tape data.

Such clarity is useful both for trading within equity markets, where high frequency traders can know prices in the various scattered markets before they are reflected in the slower tape, and for trading in correlated markets such as futures. The ability of high frequency traders to enter and cancel orders faster than everyone else also makes it hard to discern where liquidity exists across the fragmented markets. This uncertainty, in turn, creates even more opportunity for high frequency traders to exploit profitable trading opportunities both within and across markets.

The current market structure is thus highly competitive, highly fragmented, and very fast. It is also dominated by the trading of high frequency traders, who by some estimates make up half or more of all of trading volume. Understanding what high frequency traders do is crucial for comprehending why markets today are so very different from times past.

2.2. High frequency traders

High frequency trading is a misnomer, a seemingly precise term used to describe a large and diverse set of activities and behaviors. Certainly, all HFT activities have some things in common. HFT is done by computers, it relies on extremely fast speeds, and it is strategy-based. But within HFT, large differences can exist even in these common traits.

The HFT world breaks down into gradations ranging from low latency (very fast connections and trading speeds) to ultra-low latency (trading dependent on being at the physical limits of sending orders through time and space). Latency is the time it takes to send data (orders,

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