Theories for Analysing Innovation and Technology in Emerging Financial Markets: The Case of Algorithmic and High Frequency Trading

Completed Research

Wendy Currie
Audencia Business School
wcurrie@audencia.com

Ricky Cooper
Illinois Institute of Technology
rcooper3@stuart.iit.edu

Jon Seddon
Audencia Business School
jseddon@audencia.com

Ben Van Vliet
Illinois Institute of Technology
bvanvliet@stuart.iit.edu

Abstract

Theoretical and empirical analysis of complex innovation and technology from a multi-disciplinary perspective is often recommended, yet rarely undertaken in management and information systems scholarship. This paper examines high frequency trading as an innovation in financial markets enabled by sophisticated computer technology. Primary data from the US and UK is combined with secondary sources from academic studies, government agencies, financial institutions and the media on the ideologies and practices governing high frequency trading. Theoretical perspectives of rational choice theory, bounded rationality, social constructionism and Marxism are rooted in different ontological and empirical positions. Each theory prioritises distinct levels and units of analysis for HFT which, by extension, shape the research agendas for examining the regulatory processes, market structures, firm strategies and technologies of the HFT phenomenon.

Keywords

Innovation, Technology, High Frequency Trading, Regulation, Financial Markets

Introduction

Information systems scholars examine the adoption and diffusion of innovation and technology in societal, market and organizational contexts using different theoretical perspectives. While multi-disciplinary scholarship increases our understanding of how and why innovation and technology is used by industries, firms and individuals, it presents many theoretical, methodological and practical challenges for researchers. Different disciplines develop their own unique theories on social phenomena which are not easily transferred to other disciplines (Currie and Lagoarde-Segot, 2017). Research methods vary across and within disciplines with mathematical models commonly applied in economics (Lawson, 2015) comparative country analysis in political science (Hantrais, 2009) and ethnographic studies in sociology (Denzin and Lincoln, 2000). Practical considerations further inhibit multi-disciplinary study as scholars tend to submit their work to the journals within their own discipline. Barriers to multi-disciplinary research, however, are significant but insurmountable. This paper proposes that greater clarity in understanding policy-making, firm strategy, organizational and individual decision-making on innovation and technology, is sought through adopting an eclectic approach to theory-use and theory-building. Focusing on the topic of innovation and technology in developing and emerging financial markets, the paper draws from primary and secondary data from the US and UK. The focal technology is algorithmic and high frequency trading (HFT) which underpins innovation in financial markets with algorithmic

Four theoretical positions illustrate innovation and technology in emerging financial markets: 1. rational choice, 2. bounded rationality, 3. social constructionism and 4. Marxism. Each theory provides a distinctive ‘world-view’ on innovation and technology which influences policy-making agendas and decisions, industry and firm strategies, investor choices and academic enquiry. Applying these theories to the controversial practice of algorithmic and high frequency trading, this paper demonstrates how the distinct ontologies and epistemologies of each theory, frame research agendas across disciplinary boundaries. The paper is structured as follows. First, the four theoretical positions are discussed with definitions, disciplinary boundaries, main authors and key concepts. Second, the theoretical positions are used to illustrate the primary and secondary data. Finally, the paper suggests multi-disciplinary analysis using a combination of theories provides new insights for analysing innovation and technology in emerging financial markets.

**Theoretical Underpinnings**

Regulating innovation and technology in financial markets is influenced by different ontological and epistemological positions (Lagoarde-Segot and Currie, 2017). In this section, four distinct theories are discussed - rational choice theory from economics, bounded rationality from decision science, social constructivism from sociology and Marxism from political economy. Underpinned by a comprehensive worldview of the fundamental cognitive orientation of individuals and society, each theory provides an illustration of how social, political and economic influences shape action and behaviour with intended or unintended consequences. The framework presented in Table 1. outlines the distinct ideas and beliefs for each theory, which are then applied to HFT as a technology-enabled innovation in financial markets.

<table>
<thead>
<tr>
<th>Theory</th>
<th>Rational Choice Theory</th>
<th>Bounded Rationality</th>
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</thead>
<tbody>
<tr>
<td>Definition</td>
<td>A framework for formally modelling social and economic behaviour – aggregate social behaviour results from the behaviour of individual actors, each of whom is making their individual decisions</td>
<td>Idea that when individuals make decisions, their rationality is limited by the tractability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision</td>
<td>A concept of knowledge in sociology and communication theory that examines the development of jointly constructed understandings of the world that form the basis for shared assumptions about reality</td>
<td>Socio-economic analysis of markets that examines conflict and inequality using a materialist interpretation of historical development and a dialectical view of social transformation</td>
</tr>
<tr>
<td>Discipline</td>
<td>Neo-classical Economic</td>
<td>Behavioural Economics</td>
<td>Sociology</td>
<td>Political Economy</td>
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<tr>
<td>Key Concepts</td>
<td>Efficient Market Hypothesis</td>
<td>Satisficing</td>
<td>Sociology of Knowledge</td>
<td>Historical materialism</td>
</tr>
<tr>
<td>Market Orientation</td>
<td>Efficiency</td>
<td>Efficacy</td>
<td>Experiential</td>
<td>Exploitative</td>
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**Table 1. Social Science Theories for Analysing Financial Markets**
Rational Choice Theory

Rational choice theory is rooted in the discipline of economics and asserts that individuals seek to make well-judged and logical decisions. Individuals act in their own self-interest and reach decisions to benefit themselves, having considered all the choices (decision options) available. Rational choice theory assumes that individuals have preferences among the available choices to enable them to select their preferred options. These preferences are assumed to be complete. For example, an individual may select option A over options B, C and D, but also give a preferential ranking for each option (A, D, C, B). Should option A not be available, an individual may select option D in preference over C and B. The rational agent is assumed to carefully consider all the available information, probabilities of events, and potential costs and benefits in determining their preferences, and to act consistently in choosing the self-determined optimal choice of action.

In economics, rational choice theory assumes that rational individual behaviour can be embedded in microeconomic models. In modern mainstream economics, the formalistic-deductive framework which uses mathematical models, rarely questions the legitimacy of this methodological approach in the belief that mathematics is essential to all scientific enquiry (Lawson, 2015). An example is the efficient-market hypothesis (EMH) in financial economics which asserts that asset prices fully reflect all available information. A direct implication is that it is impossible to beat the market consistently on a risk-adjusted basis since market prices should only react to new information or changes in discount rates (the latter may be predictable or unpredictable).

In recent years, algorithmic and HFT which use ‘speed technologies’ have called into question the relevance of the EMH in the light of technological transformation in financial markets (Virgilio, 2015). Considering the displacement of human traders by robo-trading the EMH needs to be evaluated on the grounds of the speed which trading data and information reach investors (Hendershott et al., 2011). In modern trading environments, the time taken to send data between trading exchanges is continuously being reduced. For example, in 2010, the round-trip time taken to transmit data between New York and Chicago took 13.1 milliseconds but by 2012 this time was reduced by 3 milliseconds (Adler, 2012). The EMH (Fama, 1970) based on an economic (rational) model of man, could not foresee the vast technological changes of the past four decades that has revolutionised data and information transmission in financial markets. EMH, however, faces empirical challenges not least because of vast technology changes, but also because of disruptive market events (e.g. stock market crashes and ‘flash’ crashes). Despite the notion of ‘efficient markets’, empirical research needs to re-evaluate whether the EMH accurately describes contemporary markets as efficient, or otherwise. More general criticisms of rational choice theory, which promotes rational models of decision-making, questions the unrealistic and oversimplified assumptions about human agency (Lawson, 2015). Individuals seldom have full (or perfect) information, nor may the information be available or accessible to all individuals (information asymmetry). A recent observation about algorithmic and HFT is that information about trading strategies is proprietary, so it is not available to regulators, investors and other market participants (e.g. rival firms) (Bodek, 2013). Individual rationality is thus restricted by a lack of availability for conducting analysis to even evaluate alternative choices. Further, the more complex the decision criteria, the greater the limits to rational models.

Bounded rationality

Bounded rationality is a holistic way of understanding human decision-making. It asserts that decision-making is a rational process, albeit individuals act on the basis of limited information. Since decision-makers lack the ability and resources to reach an optimal solution, they apply their rationality to a more limited set of choices as they do not possess all the relevant information. As a departure from rational choice theory, bounded rationality emphasises that individuals seek to optimize decision choices, but face limited rationality due to the complexity of the decision problem, the cognitive limitations of their minds, and the time and/or finances available to make the decision. Simon (1955, 1957) developed the concept of satisficing to illustrate how decision-makers seek a satisfactory (rather than optimal) solution. Bounded rationality offers an alternative to mathematical modelling of decision-making in economics (and other disciplines).
Simon’s work complements ‘rationality as optimization’ which underpins decision-making as a rational process that seeks an optimal choice from the available information. Simon contrasted two scenarios: cognitive limitations of individuals with structures of the environment, to illustrate how individuals compensate for their cognitive limitations by exploiting known structural environmental regularities. Researchers from the field of behavioural economics have extensively used Simon’s work to illustrate how and why human behaviour commonly departs from rational choice explanations or more traditional forms of economic rationality. Bounded rationality and satisficing applied to financial markets show trading decisions are not wholly explained through rational economic models, since they involve complex choices which rely on other criteria, e.g. judgement, gut-feeling, rules of thumb, and even fear and panic. In algorithmic and HFT, innovation in trading practices enabled by high speed technologies driven by sophisticated algorithms, have largely removed the human element from trading, at least at the point of execution. Algorithms running under statistical control now drive trading decisions, based on the involvement of the ‘quants’ (mathematicians and programmers) rather than finance professionals (Davis et al., 2013). Recent work questions whether HFT maximizes capability (by Cooper and Van Vliet, 2015) or whether it searches for strategies to achieve an aspirational level (Von Neumann and Morgenstern, 1947). Lacking adequate information to for optimization due to the infeasibility of a thorough search, suggests HFTs are capability satisficers.

Criticism of Simon’s work focuses on its limitations as a descriptive model for policy-making. Theoretical approaches of rational choice and bounded rationality make assumptions about the intellectual capacity of man, how individuals attach values to preferences, and about access and resources which either facilitate or inhibit decision choices. to time and money that organisations have (Lindblom, 1959). Both theories tend towards a minimalist characterisation of innovation and technology in financial markets, with little critical reflection on the substantive problems, such as the exogenous and exogenous conditions which either cause or correlate to disruptive events, such as financial or flash crashes.

**Social Constructivism**

Social constructionism or the social construction of reality is a theory of knowledge in sociology (Berger and Luckman, 1966). Socially constructed understandings of the world form the basis of shared assumptions about reality. The theory examines how human beings rationalize their experience by creating models of the social world and share and reify these models through language. Social-constructionist ontology examines how individuals and groups work together to construct artefacts, participate in the construction of their perceived social reality, and create, institutionalize and maintain social phenomena. A social construct or construction considers the meaning, notion, or connotation attributed to an object or event by society, how it is interpreted by individuals and groups, and the actions they take in regard to the object or event. A social construct accepted in one society may not be embraced by another. Over the past few decades, social constructionist theory has engaged the work of sociologists, with studies examining innovation and technology as an emergent process (Latour, 1987). The focal interest is how science characterizes objective facts to elucidate processes of social construction, with the aim of demonstrating how human subjectivity imposes itself on those facts considered to be objective by the wider society.

The intellectual antecedents of social constructionism are found in ‘symbolic interactionism’ (Denzin, 1992) and ‘phenomenology’ (Husserl, 1963). Further work on the ‘social construction of reality’ strengthened the theory in mainstream sociology (Berger and Luckman, 1966). Researchers use social constructionism to understand financial markets, innovation and technology (Knorr-Cetina and Preda, 2013). Contributions on the ‘sociology of algorithms’ examine financial innovation and technology, not simply as material artefacts, or whether algorithmic and HFT increases the market efficiency, but also how individuals shape their social and cultural environments at the same time as being shaped by them. Some HFTs may simply look to satisﬁce their economic returns rather than seek optimal outcomes. Sociological perspectives applied to innovation and technology seek to determine how social processes are “both revealed and concealed, created and destroyed by our activities.” (Pearce and Foss, 1990).

In social constructionist terms, the focus on ‘taken-for-granted realities’ that derive from ‘interactions between and among social agents’ departs from rationalist approaches that aim to reveal an objective reality using formalistic (mathematical) deductive models (Lawson, 2015). Instead, social constructionism presents multiple conflicting realities that represent meaning and legitimacy. Social constructionism is
used widely in language and communication studies and in discourse analysis. The view that language does not simply mirror reality, but instead constitutes or creates it (Fairhurst and Grant, 2010) is fundamental to interpretive approaches in sociology, particularly for understanding how individuals and groups perceive the impact of to understanding innovation and technology on financial markets, investors and society at large. Social constructionism has invited theoretical and methodological criticism from many intellectual traditions similar to those directed at other interpretive (non-positivist) accounts of knowledge creation (Boghossian, 2006). Social constructionism tends toward the nurture end of the nature–nurture spectrum. It attracts criticism for overlooking the biological influences on human behaviour and culture, and by ignoring or underplaying the complexity and diversity of societal outcomes. A more nuanced understanding of the nature–nurture relationship for explaining behaviour and cultural phenomena is sought.

**Marxism**

Marxist accounts of innovation and technology are centred around core concepts including historical materialism, which is a methodological approach to study society (Marx, 1849). It asserts that technological advances in *modes of production* change the social relations of production. Historical materialism depicts the underlying reality of human existence. For human beings to survive, they need to produce and reproduce the material requirements of life. Marx developed this premise by asserting that, in order to carry out production and exchange, individuals have to enter into clearly defined social relations or *production relations*. The economic foundation of society supports and shapes the ideological *superstructure* which encompasses culture, politics, and other facets of human social consciousness. The aim is to identify the *causes* of events and changes in economic, technological factors, and how conflicts of *material* interests among individuals and groups play out in society.

Marxist interpretations of innovation and technology in financial markets are oriented towards an agenda that examines the existence of exploitative social relationships rather than one that places rational actor or market efficiency at centre stage. In Marxist theory, the dialectic between those who own and control the *means of production* and those who sell their labour (e.g. exploiters and exploited) is made more complex by financialization and the fragmentation and deregulation of global financial markets (Lapavitsas, 2011). Algorithmic and HFT are complex socio-technical systems which attract interest from across the social science disciplines. While rational choice and bounded rationality theory from economic perspectives examine social relations about rational decision choices, Marxist accounts examine the material conditions which shape financial trading in the modern world. Studies from economics, political science and sociology have tackled issues of inequality and fairness (or lack of) in financial markets even though many authors do not formally position their work from a Marxist perspective. Marxist concepts and ideas provide a basis for analysing material and informational inequalities in financial markets between individuals, firms and even nation states (Lapavitsas, 2009).

Algorithmic and HFT resonates with Marxist theory since it is a controversial form of financial trading (Lewis, 2015). At the regulatory level, information systems research points to issues about lack of transparency (information asymmetries) between the regulator and the HFT firms being regulated (Currie and Seddon, 2017). Other studies more closely examine the complexity in social and economic relations in the context of the ‘spatial and material frictions’ as HFT’s pursue sub-millisecond advantages (Toscano, 2013). HFT characterises the shift from human agency, ‘physical’ trading pits, and material trading exchanges, towards ‘algo’ or ‘robo’-trading using complex mathematical programs, state-of-the-art co-located data centres with the matching engines that execute buy and sell orders, enabled by fibre-optic cables between New York and Chicago that reduce speed of transaction by 3 milliseconds at a cost of a $100 million per millisecond (MacKenzie, 2014).

While this scenario plays towards a Marxist perspective since it implies that those with the financial, technological and strategic resources to gain an advantage over others will inevitably result in financial market inequality, the potential for multiple conflicts and contingencies that underpin modern financial trading need to be closely examined. The material and spatial shifts in financial trading driven by innovation and technology over the past few decades have benefited some at the expense of others. For example, HFT firms with access to the ‘best brains’ (quants programmers and mathematicians) and the latest technology, has caused some to question the ‘fairness’ of the practice (Angel, 2012). Strategies,
The extent to which HFTs gain competitive advantage from enhanced processing power and speed provides a technological explanation of the transformation in contemporary financial trading. Yet an extended analysis of the hierarchies, networks and practices that govern these changes, using Marxist and other social theories, will contribute to the intellectual debate. A potential criticism of Marxist accounts is the inevitability that HFT is an exploitative practice that depersonalises, detaches and deskills human traders in an ‘algorithmic revolution’ (Toscano, 2013) characterised by the removal of traditional trading ‘pits’ to fully automated trading activities located in remote data centres. Other concerns about the disruptive material and spatial features of HFT have led to descriptive and analytical confusion about financial market events such as the 2010 Flash Crash. While HFT is correlated with this event, as HFTs demanded immediacy over other market participants, it was not found to be the cause (Kirilenko et al, 2014). Others, less favourably disposed to HFT, argue that HFTs tend to create financial market volatility which may lead to flash crashes (Fairless, 2016). Critics of Marxist perspectives refer to an oversimplification in how social relations are represented in society. Concepts of historical materialism, while focusing on the material inequalities of economic exchanges between capital and labour, tend to overlook the subjective influences of ideas, culture and customs which form the basis of the superstructure.

Methods

The study began in 2015 as an exploratory investigation of financial innovation and technology in the US and UK. Research funding was obtained to support visits to financial industry firms to collect primary data. The preliminary research question asked informants: Describe how innovation and technology is changing financial markets?

Building on the research question in conjunction with carrying out an extensive literature review, the study became oriented towards the phenomenon of algorithmic and HFT as a major innovation in emerging global financial markets. Prior studies encourage a wider research agenda on themes and issues beyond the technicalities of financial innovation (Funk, and Hirschman, 2014) to include, the regulatory control of financial markets evolving financialised capital and inequality (Piketty, 2014), fairness and ethics in financial trading (Angel, 2012) the displacement of human traders with robo or algo trading (MacKenzie, 2014), and market efficiency and algorithmic trading (Hendershott et al, 2011). Further, a multi-disciplinary approach combining different theoretical perspectives to provide a richer and more nuanced understanding of innovation and technology in financial markets was sought.

The results discussed in this paper are based on interviews with HFT firms (7) non-HFT firms, or low frequency traders (LFTs) (3) and a regulator based in the UK (1). HFT firms located in north America (5) and the UK (2) (plus 3 LFTs) were interviewed to capture the essence of how HFT is changing financial markets, for better and worse. The primary interviews, all of which were digitally recorded lasting at least 1 or 1.5 hours, gathered data and information on five themes: regulation, market structure, strategy, technology and risk. Open-ended questions provide a useful entry-point for building on key themes relating to social phenomena (Denzin and Lincoln, 2000). Secondary data collected from scholarly literature, financial regulators, HFT firms, business analysis and consultancy organizations, and the media, supplemented the primary data.

Discussion

The four theoretical positions outlined above are represented in the comments obtained from the informants from the HFT firms. HFT has gained considerable attention from economics, sociology, law and ethics scholars over the past decade and is a form of computerized financial trading which uses proprietary algorithms (Currie and Seddon, 2017) in two forms: 1. execution trading is when an order (often a large order) is executed via a computerized algorithm. The program is designed to get the best possible price. It may split the order into smaller pieces and execute at different times. 2. small trading which seeks market opportunity with estimates that 50 percent of stock trading volume in the U.S. is currently being driven by HFT (Nasdaq, 2017). Following data collection and analysis, a selection of the informants’ comments is organised under the four theoretical positions illustrated in Table 2. The striking observation from the aggregated data is the diversity in the comments, ranging from HFT traders who
focus on the narrow issues of market efficiency and stability to others who believe that HFT is an unfair practice that requires further regulation and oversight.

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<tr>
<td><strong>HFT Regulation</strong></td>
<td>'Making HFT become more responsible for self-regulatory activities increases both investor protection and market stability.' (HFT#2)</td>
<td>'Information asymmetries prevent regulators from effective oversight of HFT firms. The HFTs have all the cards'. (HFT#5)</td>
<td>The speed, cost and social value of HFT are all considerations for regulators. The issue is whether you see HFT as a social and economic good'. (Reg#11)</td>
<td>'The regulators are trying to level the playing field, but they are always playing catch-up'. (HFT#10)</td>
</tr>
<tr>
<td><strong>Market Structure</strong></td>
<td>'Here in the US, the market is both fair and efficient. Speculation causes bubbles which quickly burst and prices always return back to their true value.' (HFT#3)</td>
<td>HFT make continuous profits because they trade on market inefficiency, something that is simply not available to the traditional broker or investor (LFT#6)</td>
<td>'Institutional investors have expressed serious reservations about the current equity market structure in terms of fairness and transparency'. (Reg#11)</td>
<td>'The markets are rigged. (HFT#7) HFTs get advance news which results in institutionalised front-running'. (HFT#5).</td>
</tr>
<tr>
<td><strong>HFT Strategy</strong></td>
<td>'Often, HFTs provide the market with increased liquidity which is a by-product of their strategies. This reduces the frictional trading cost' (HFT#1)</td>
<td>'It’s simply not possible to search through all of the available strategies to optimize how they operate, we are limited by time, risk and technology' (HFT#8)</td>
<td>The SEC fined us for front-running. We did not admit to this, but we paid the fine. It’s the cost of doing business'. (HFT#2)</td>
<td>'HFT strategies are predatory and disruptive to markets. They do not guarantee liquidity as specialists did' (LFT#6)</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>'The use of fast networks, co-location or advanced technology is available to all. Any company can use this to trade in todays fragmented market'. (HFT#1)</td>
<td>'HFT is secretive about what it does and how it works. We have to use statistical checks all of the time to make sure we are running in control' (HFT#3)</td>
<td>'We are in a technical arms-race because we are competing with other HFT’s for fleeting profit opportunities. We have got to be the quickest' (HFT#4)</td>
<td>'HFTs compete on speed to give them an unfair advantage over non-HFTs'. (LFT#7)</td>
</tr>
<tr>
<td><strong>Ethics</strong></td>
<td>'The reduction in the cost of trading, with lower buy and higher sale prices, has benefited the long-term investor and made the market more competitive' (HFT#4)</td>
<td>'By default, the market is not efficient; it has to be made efficient. This activity is now done by HFT as they create price discovery' (LFT#7)</td>
<td>'Automation has changed the market. Why should the regulator be concerned with anyone other than the long term investor?' (HFT#9)</td>
<td>'HFT have no interest in securities. They simply take profits away from the market and their activity causes instability' (LFT#6)</td>
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Table 2. Theoretical perspectives to illustrate Informants’ views on HFT
Informants’ comments on HFT were based upon their perceptions, experience and views about how financial markets operate, and their role as financial professionals. Interviewees in HFT firms rarely questioned issues and debates about fairness of HFT practice, and an emerging two-tier market, with HFTs gaining advantages over non-HFTs, or LFTs, due to speed of, and access to, the most sophisticated technology. Conversely, LFTs voiced concerns about the ‘damaging effects’ of HFT on market efficiency, with some (LFT#6) suggesting that HFT should be eliminated, or at the very least, ‘more tightly regulated’. One ex-HFT trader, working with the regulator having closed his firm due to ‘institutionalized front running’ among other predatory HFT strategies unknown to his firm, was particularly critical about the deleterious effects of asymmetrical information. He pointed to HFTs working closely with the exchanges to gain significant benefits from paying for co-location services to maximize speed of access to execute buy-sell orders. Such advantages were beyond the financial scope of non-HFT firms, and even some HFTs without access to proprietary knowledge and financial resources. Commenting on this issue he said, ‘This stuff is very complex. Even many financial market professionals don’t understand the inner workings of (financial) market microstructure. The regulators are working to prosecute bad practice, but the cases are complex, time-consuming and expensive’ (HFT#5).

Information asymmetry not only distinguishes those with access to financial market data/information from those without, but also the extent to which people make rational choices based upon the (bounded) information available to them. Concerns about the ‘cumulative effects of asymmetries’ and ‘non-transparent asymmetries’ extend towards preferential market access, superior pricing structures, captive order flow arrangements, and complex order types, some of which blur the boundaries between legality and illegality. While HFT firms focused their time and resources on building their sophisticated technological assets, using the skills and expertise of ‘quants’ programmers (mathematicians and engineers), relying less on traditional finance professionals, the LFTs expressed concerns about the changing business models in financial markets, and how HFT is (socially constructed) as an enabler of market efficiency. While LFT voiced this opinion in terms of their own experiences of how their traditional business arrangements were being disrupted by HFT, others were more radical in their criticism, not just about HFTs but also, the role of financial regulators as well as the ‘neo-liberal policies that have led to financial market de-regulation and fragmentation’ (LFT#7).

The interviews across the 11 organizations provide an illustration of innovation and technology in modern financial markets, enabled by sophisticated computer infrastructure and software which has disrupted traditional forms of equities and securities trading (Freedman, 2006). Findings show a wide range of views and opinions on HFT which reflect the cognitive and experiential disposition of informants. The theoretical perspectives used to illustrate the data range from rational-analytical responses on the inner-workings of HFT to achieve profitability as efficiently as possible, to experiential accounts that raise concerns about the social and economic impact of HFT on traditional market participants and society at large. Theoretical perspectives from economics and sociology provide a rich picture of how HFT, as an innovation in financial markets, is perceived by different groups, and even by individuals within the same or similar groups. While rational choice and bounded rationality accounts offer detailed scrutiny of decision processes, the unit of analysis is largely around individual action and behavior. Social constructionism and Marxist accounts extend this analysis by examining societal and market effects and outcomes of innovation and technology. Although this paper provides only a snapshot of the diversity of views and opinions on HFT, it contributes to multi-disciplinary studies which seek to integrate different levels and units of analysis to analyse the HFT phenomenon.

**Conclusion**

This paper makes three observations. First, it supports a multi-disciplinary approach which combines different theories to reflect the diversity of informants’ opinions, views and comments based on their different cognitive and experiential orientation towards HFT (Currie and Lagoarde-Segot, 2017). The four theoretical perspectives show HFT firms place less emphasis on the wider political, social and economic dimensions of HFT, unlike the LFTs, who voice serious dissatisfaction about the lack of regulatory oversight. Second, the emergence of a two-tier market needs further theoretical and empirical investigation, with economic analysis combined with sociological and political economy accounts. Rational choice and bounded rationality approaches are strengthened by sociological contributions which consider the wider societal and market implications of HFT, not only as a technological means to
‘compete on speed’ (Pagnotta and Phillippon, 2015) but also as a game-changer or disruptor of traditional financial business models (Kirilenko et al, 2014). Third, the themes and issues discussed in this paper relate to wider debates on financialization, globalization and marketization (Lazonick, 2010), which tend to ‘black-box’ innovation and technology as an enabler of these emergent processes. An opportunity therefore exists for information systems researchers to contribute more fully to these debates by examining technological artefacts, in the form of HFT and others (e.g. blockchain), in conjunction with ongoing public policy debates about regulation and oversight in increasingly automated financial markets.

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