A Sociotechnical Analysis of High Frequency Trading

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Introduction

On May 6, 2010, a trillion dollars' worth of economic value was wiped out from the economy, all within a span of 36 minutes (Kirilenko et al., 2017). Stock prices plunged rapidly in what seemed to be a near catastrophic series of events. Just as reminders of the Crash of 1929 filled the minds of traders, prices rapidly recovered. After this "flash crash," regulators and traders immediately began looking for the root cause of this event. The ability to influence market prices at this scale was unprecedented, and eventually, high frequency traders were found to be the perpetrators.

In capitalism, every purchasable asset has some sort of financial representation, such as cash. Across centuries, financial instruments, from securities to bonds, have been formulated to model the complex dynamics of the financial world (Hu, 2011). Trading flourished around these financial assets, leading to the need for an exchange. An exchange is a platform through which buyers and sellers buy and sell, confident that each party will meet a counterparty to trade with. The ability to fulfill these trades is called liquidity, a necessary property of an exchange (Britannica, 2018). Today, billions of trades are made daily on exchanges (NYSE, 2019). However, the ability to match billions of trades coming in at multiple exchanges around the world is a technological challenge, a feat too difficult for humans to manually achieve. This need lead to the birth of high frequency trading (HFT).

With the breakthroughs in computational technology in the 20th century, computers have made it possible to conduct millions of trades per day. HFT firms have leveraged computers to gain tremendous influence over financial markets. Indeed, the Flash Crash of 2010 resulted from massive selloffs from these computers, only to be followed by massive buybacks. The immense

influence of HFT over financial markets brought in skepticism about the net value they provide. While HFT traders can potentially serve as critical market makers who increase liquidity in exchanges, they can also manipulate prices and disrupt healthy markets. This paper addresses how HFT firms gained infamy among market participants, despite their ability to enhance financial markets. Understanding the societal and technological elements behind HFT will be critical, as their presence in the financial world is becoming ever more significant.

To reiterate, for the STS topic, this paper explores how HFT firms received skepticism from market participants, despite their ability to provide liquidity to financial markets. Addressing and understanding the fundamental role of HFT firms is important in justifying their value as market makers or price manipulators. In this paper, the role of HFT firms is navigated through the Social Construction of Technology (SCOT) framework.

Research Question and Methods

Why are HFT firms, despite their beneficial market making activity, luring in distrust from other market participants? Through policy analysis, the context of the problem is outlined before analyzing approaches that have been taken so far by regulators and exchanges toward HFT firms. The effectiveness of current or previously-considered policies in curbing market manipulation and increasing liquidity is analyzed. Any downsides of these policies are also considered in order to provide a holistic viewpoint of areas where HFT firms are questionable in their liquidity-providing functions. In addition to current regulations, which are publicly available online, scholarly articles provide unique perspectives to this topic. Scholarly sources on the impact of various regulations, both former and current, shed light on the complexities of enforcing and unexpected consequences of certain policies.

Through network analysis, the complex relationship between HFT traders, market participants, investors, and regulators is examined to see how one actor can impact another party. Understanding the dynamics of how HFT firms can harm or help market participants in fulfilling their liquidity needs while pleasing investors is critical. Regulators, who seek to encourage market making activities from HFT firms, must also consider the ramifications of regulations on investors and other market participants. Similar to the resources used for policy analysis, various viewpoints on HFT firms must be considered in constructing a network of involved participants, as it is critical to define distinct parties with unique interests to properly define, assess, and enforce regulation.

STS Framework

In this paper, the Social Construction of Technology (SCOT) framework is used to understand the contextual role of HFT. The SCOT framework is the framing of a technological phenomenon in terms of stakeholders, societal context, and technology. In this case, the interaction between market participants, regulators, traders, and exchanges constitute the involved stakeholders. Computational technology, specifically the servers exchanges and traders use to send buy and sell orders, is the primary technologies involved. For HFT firms, the high-performance hardware and software they use to conduct rapid trades at scale constitutes their technology stack. Ultimately, through this framework, how traders leverage this technology to conduct trading activity and how regulators attempt to deter manipulative trading activity without harming other parties are investigated. By understanding the dynamics between trading technology, market participants, and regulators, this paper explores how the actions taken by each party in this context influences the rest of society in terms of economic and societal factors.

An important property of the SCOT framework is that human action shapes technology. As such, understanding each involved party is a critical element in framing HFT, since doing so requires seeing how people leverage technology to fulfill their interests. However, the SCOT framework is limited in that it superficially addresses the consequences of HFT in a broader context and rather, specifically focuses on how people change technology and the significance of doing so. In addition, it avoids analyzing the deeper cultural components behind HFT as a technology. Nevertheless, the cultural elements in HFT is not seen as important in understanding the topic at hand and will not be explored in this paper.

Michael Lewis is a famous critic of HFT and the author of *Flash Boys*, a top-selling book highly responsible for initializing distrust towards HFT. In his book, Lewis analyzes the relationship between different institutions in the financial markets, seeing how HFT has "rigged" every market in the world. By leveraging the SCOT framework, Lewis illustrates the relationships among investors, HFT traders, exchanges, and other market participants and how HFT traders and investors are essentially taking money from other market participants by partaking in manipulative trading strategies (Flash Boys, 2020). However, Andrew Ross, a Professor of Social and Cultural Analysis at New York University, criticized the book for oversimplifying these relationships and how HFT firms are not to be villainized but rather, stock exchanges, who profit by selling HFT traders fast access to exchange servers (Sorking, 2014). With Ross and Lewis both being advocates of the SCOT framework, seeing it as a comprehensive approach to understanding techno-societal events, their contrasting perspectives hold relevant to this paper. They both see technology as instruments used by humans to fulfill a certain need and that ultimately, people are to be held responsible, not technology. Understanding different viewpoints on which party to attribute fault to is important, since it

shows how the vilification of HFT by market participants came to rise and the complex relationships each stakeholder has with each other. Indeed, determining whether or not HFT is immoral or unjustified is not straightforward and requires breaking down complex relationships between stakeholders and understanding how specific interests manifest into different types of actions. Hence, the SCOT framework provides the necessary tools to better understand to navigate the complex landscape of HFT.

Results and Discussion

The skepticism among market participants toward HFT is driven by a combination of factors: the complicated technical nature of HFT, *Flash Boys*, and regulation challenges. Despite the negative perception towards HFT, HFT increases the efficiency of financial markets by providing liquidity at an unprecedented scale, decreasing transaction costs for market participants and synchronizing prices (Gerig, 2012). However, as with any new technology, directly involved market participants naturally question the societal value it adds, and HFT is no exemption. In addition to the challenges of societal acceptance, regulators must formulate coherent policies to deter individuals from abusing new technologies. Through the SCOT framework, supplemented with network and policy analysis, the fundamental role of HFT and the perception towards it can be understood in terms of its societal, regulatory, and technological components.

First, in order to understand how HFT fits in the SCOT framework, it is essential to categorize involved parties: exchanges, HFT traders, market participants, and regulators. Exchanges refer to general platforms through which trades, specifically buy and sell orders, are sent and fulfilled. HFT traders refer to any entities or individuals who leverage HFT technology to trade. Market participants refer to any entities or individuals who conduct trades (by buying or

selling an asset) on an exchange. Lastly, regulators refer to any governing authorities in finances. The scope of this paper refers to HFT activities in the United States, where a majority of HFT activity takes place. Hence, the Securities and Exchange Commission will be the primary regulating body that is referenced in this paper.

Building upon the SCOT framework, it is critical to understand the stakes held by each involved party in the realm of HFT. To begin with, exchanges conduct business by selling access to trading platforms, which market participants use to fulfill their liquidity needs. For example, a market participant who wishes to sell an asset can pay a small fee to an exchange to sell those assets to a buying counterparty on an exchange. Essentially, exchanges make it possible to match buy and sell orders to ultimately provide liquidity to market participants while profiting from exchange fees. However, exchanges also generate significant revenues by giving HFT firms special access to exchange servers (Gomber, 2015). HFT firms pay exchanges to have low-latency access to the exchange's computer servers so they can rapidly find profitable trading opportunities. As such, exchanges strive to provide liquid markets for market participants while selling profitable opportunities to HFT firms.

The goal of a HFT trader is to find profitable trading opportunities, many of which exist for only nanoseconds. Ultimately, the profits from such trading activity are intended to maximize returns for investors who have put money into these HFT firms. Naturally, their trading activity usually results in market making. Regulators are incentivized to pass laws that ensure HFT activity is beneficial for financial markets. Regulators must design laws that deter market manipulation activity and incentivize competition among HFT firms. Lastly, market participants are incentivized to execute and fulfill their liquidity needs at the best price possible. Naturally, market participants tend to buy and sell on exchanges that provide the highest-quality execution

where buy orders are fulfilled at the lowest prices possible and sell orders are fulfilled at the highest prices possible, hence, maximizing profits. Thus, market needs drive HFT firms to produce faster and more scalable trading algorithms in order to continuously increase liquidity. This can be seen in the massive investments HFT firms have made in high performance computer servers and high bandwidth networks (Othman, 2012). In spite of the negative perception of HFT among participants, the ever-increasing trading volumes continues to drive innovation in trading technology as demand for liquidity grows. For example, HFT firms are investing more money than ever before in researching novel computer hardware, such as extremely fast, custom-built CPUs (Puorro, 2013). This hardware is used in powering ever-faster calculations and algorithms for trading.

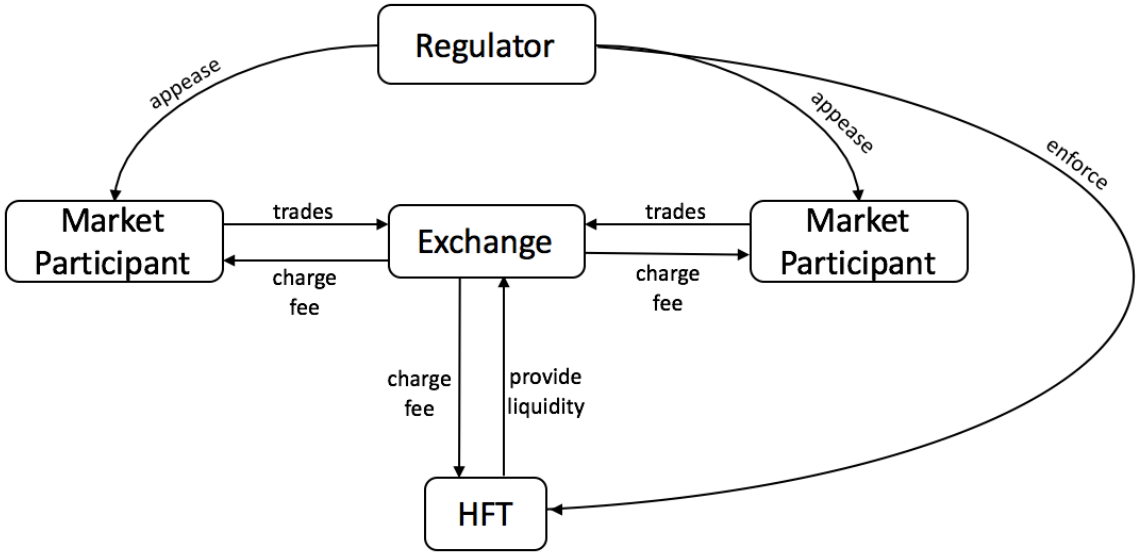

Figure 1: Network of Involved Stakeholders

It must be understood that HFT produces practical value for society and how society is reacting and how skepticism has affected trading technology and regulation. The misgivings surrounding HFT from market participants are fundamentally driven by various factors. First, the

complex symbiotic relationship between HFT traders and market participants is not immediately tangible. Second, the popularity of *Flash Boys* has instilled a negative perception of HFT among market participants. Third, regulators face complex challenges and face unique scenarios when implementing regulation that are conducive to fair and efficient financial markets.

Market making, the process of matching buyers and sellers, is a fundamental operation of an exchange, and HFT traders provide market making services through these exchanges. As the number of market participants and trade volume in exchanges grow, computer automation has taken the place of manual and painfully slow human market makers (Othman, 2012). HFT is an exemplary illustration of how humans leverage computer automation, where rapid, high-performance computers are utilized to match trades at unprecedented scale. Indeed, HFT is a natural development for financial markets, where trading volume has skyrocketed and market participants demand orders be fulfilled as fast as possible. However, the majority of market participants do not see HFT as essential in improving markets. This is mainly due to the secretive nature of HFT. From a market participant's perspective, they directly trade and work with exchanges. However, within the inner workings of an exchange is HFT, which provides the automation and scale to match the billions of trades sent on exchanges every day. In addition, HFT firms are extremely secretive by nature because competitors relentlessly strive keep trade secrets hidden from each other. This is seen in extremely long non-compete and non-disclosure agreements HFT employees must adhere to (Bunge, 2009). As such, they tend to shy away from public attention, resulting in market participants being generally unaware of and distanced from HFT. However, HFT powers every modern exchange and play an important role.

In addition to the elusive nature of HFT, *Flash Boys* is a significant contributor to HFT skepticism among market participants. Upon the book's release, there was a spike in mistrust

toward HFT among market participants. Later in the same year the book was released, a poll conducted among "financial industry participants, showed that nearly 70% of participants believed markets were "rigged" by high frequency trading firms (Cox, 2015). Among those asked in the poll, many expressed sentiments shared in the book, stating that predatory HFT trading activity would artificially make security prices expensive to participants. The book became popular not only among market participants but also the general public. At one point, Sony Pictures started talks with Lewis on creating a movie based on the book due to its popularity (McNary, 2018). However, the book's release did not only trigger a cascade of scrutiny from market participants. Regulators, who must appease their constituents, market participants, began initiating a series of investigations into HFT firms. Later in the same year the book was released, the SEC initiated a probe into 10 of the largest HFT firms. The probe involved collecting complaints and tips from various market participants with the goal of possibly indicting firms for many of the same accusations voiced in *Flash Boys* (McCrank, 2014).

Although no crimes were found among the probed firms, the skepticism towards HFT is continued to be driven by the regulatory challenges regulators must face when deterring price manipulation, the practice of temporarily shifting asset prices to create a profitable trading opportunity. Spoofing is one method of price manipulation, where a trader transmits a large buy order to artificially inflate the price of an asset, cancels the order, and then sells the same asset at the inflated price, hence, making a guaranteed profit (Dalko, 2018). The ambiguities of defining price manipulation and the technical challenges of detecting disruptive trading continues to be a problem for regulators today, exacerbating the distrust towards HFT.

The Dodd Frank Act enables the Security and Exchange Commission to prohibit disruptive trading practices (Miller, 2015). However, enforcing such a provision on the HFT world is challenging. High-speed computers generate millions of bids and offers and can cancel orders in less than a second. As such, to monitor and detect a disruptive transaction, such as spoofing, is an overwhelming technical challenge. In addition, defining a trade as manipulative is ambiguous. Any trade, whether small or large, shift prices to some extent. There is no definitive principle that decides whether or not a trade was sent for the purpose of manipulating prices. Currently regulators approach suspicious traders by asking traders to explain the reasons behind a transaction, but such a process is vague and open to interpretation (Puorro, 2013). The trader can justify a transaction with many different reasons. Because market participants are not guaranteed that they safeguarded from HFT manipulation, the fear of HFT has naturally become instilled in the minds of participants. The increased scrutiny of HFT has increased the capital expenses of operating HFT businesses. Legal costs have skyrocketed for these firms. In addition, the demand for transparent markets has pushed HFT firms to invest in separate servers to log all activity data in the case of a lawsuit (Kirilenko, 2017). Shifts in societal perception of HFT has fundamentally changed HFT technology, both in operational requirements and capital expenses. Now, having dedicated servers for legal reasons, in addition for regular trading activities, is a requirement in this current climate. With the increasing operating expenses of operating a HFT business, there has been a consolidation in the sector, with bigger players doing even better as smaller players succumb to increased legal expenses (Dalko, 2018), demonstrating how can drastically influence the development of HFT technology by through regulation and scrutiny.

Although in recent years the scrutiny of HFT has gradually abated, more than half of market participants continue to hold the belief that markets are not fair (Cox, 2015). The

difficulty of connecting more efficient markets to HFT activity is a significant factor for HFT's infamy. However, by seeing the positive effects of HFT activity on exchange efficiency metrics, it is clear HFT allows for more liquid markets, lower order execution fees, and better asset pricing.

The liquidity improvements HFT gives to exchanges is measured in order fulfillment times. With the onset of HFT, the average time it took to fulfill an order drastically decreased. In the 1970s, orders had to be manually fulfilled by humans who would call multiple exchanges to find counterparties to match trades with. This process would involve multiple traders filing paperwork and countless calls, a process that could take several days. But with the advent of computer automation, exchanges could begin fulfilling millions of trades in milliseconds and at scale instead of relying on cumbersome and expensive human labor (Gomber, 2015). These developments lead to lower execution fees for market participants, as exchanges began competing with each other for more business with their technologically-enhanced order matching services.

In addition to lowering execution fees and increasing liquidity, HFT has allowed for better price discovery for assets. HFT algorithms tend to buy or sell in the direction of permanent price changes and the opposite for short-term price pricing errors. Having more accurately priced assets is a critical property of an efficient market, since price accuracy directly translates to more stable prices. This synchronization of asset prices is seen in the narrowing of the bid-ask spread, the difference in average selling prices and buying prices (Jones, 2013). By "centralizing" trades around a fundamentally-supported price, HFT expedites price discovery. A consequence of improved price discovery is reduced volatility, another benefit for markets. With the narrowing of the bid-ask spread, prices tend to move more in unison with an asset's fundamental value, an

inherently stable property. In essence, better price discovery is a product of consolidating price differentials. Price stability hedges against the risk of losing significant amounts of money from volatile price movements, a valuable property market participants look for. Hence, HFT has decreased risk for market participants and allowed for more accurately-priced assets (Hendershott, 2012). Market demand continues to drive HFT business and technological development, particularly in high performance computer technology. However, increased regulation, a result of distrust among market participants, has also fundamentally changed HFT technology and business operations, as mentioned earlier. This demonstrates how societal dynamics, regulations, and market demand can drastically affect the development of HFT.

One limitation of this research is understanding the cultural elements behind why market participants fear HFT. This is an inherent shortcoming of the SCOT framework, since it focuses more on the relations between stakeholders, societal context, and underlying technology of a sociotechnical phenomenon. In this case, the challenges of regulating HFT, the different ways each party affects each other, and the ways high-speed computers are redefining markets are investigated to understand why HFT is perceived negatively despite its beneficial role. However, the cultural elements surrounding HFT, specifically around computers automating away human jobs, could be a significant reason behind the negative perception towards HFT.

This paper only addresses the STS elements of HFT in the context of the United States. However, HFT regulation and perception differ around the world, and conducting an analysis country by country would yield unique insights. For example, among European exchanges, HFT is not as widely accepted among regulators (Jones, 2013). HFT activity is rapidly permeating markets on a global scale. Governments are taking action to better understand and regulate HFT, but policies differ country to country. This is natural, as different exchanges trade different asset

classes and experience varying levels of trading volume. Nevertheless, the fundamental nature of HFT as a hyper fast market maker holds for all kinds of markets. Extending my policy analysis within the context of the SCOT framework by analyzing how different countries are approaching HFT would be effective in seeing which regulatory approaches work and which do not.

Conclusion

What are the sociotechnical factors behind the disconnect between HFT's beneficial market role and the negative perception surrounding HFT? In essence, it is the lack of understanding of HFT's complex market making role and the difficulties in regulating HFT. The onslaught of regulatory scrutiny, fueled by broader distrust, has changed HFT technology. As per the SCOT framework, it is clear that societal perception can ultimately change how certain technologies evolve. However, HFT is not unique in this regard; throughout history, the onset of any new technology generally brought upon an initial wave of skepticism and distrust that can affect technological development. Resolving this issue requires properly educating participants on the essential role HFT plays in markets. In addition, the technical challenge of monitoring and identifying disruptive HFT trades is an immediate obstacle that must be resolved. Nevertheless, HFT is a natural step in the evolution of modern markets, but as with any new technology, societal acceptance is never a straightforward process.

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