What is known about High-frequency trading

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Abstract

This research overviews recent theoretical and empirical studies on high frequency trading (HFT). The presence of algorithmic trading (AT) and its subset high frequency trading (HFT) in today's computerized and networked markets has made discussions around risks and benefits of HFTs. Use of HFT has increased dramatically during the last decade. This research investigates different aspects of high frequency trading (HFT). In this literature review the various perspectives of previous studies on the field of HFT are reviewed. Then body of literature on HFT impacts on market quality measures is reviewed. Finally, HFT profitability, performance and regulatory issues are summarized.

Keywords: high-frequency trading, algorithmic trading, market quality, profitability, regulation

1. Introduction

Today, virtually most of trades on capital markets are carried out via complex, automated and high speed algorithms. These computer programs are continuously evolving with faster computers and networks. In recent years, technological progress, financial innovation and growing access to the huge amount of market data in financial markets have resulted in increasing algorithmic trading activities and its subset high frequency trading (hereafter HFT). Advances in computing power and improvements in communication networks have facilitated the development of HFT. HFT is actually one of the major recent innovations in financial markets. HFT in financial markets have been making media headlines during recent years. As a relatively novel phenomenon, much of the discussion is not backed by solid academic research.

Although HFT now makes up a large portion of the global equity markets activity especially in the U.S., the academic analysis of its role and effects in the financial markets is in its early stages. Rapid diffusion of HFT activities in markets has advanced research by both academics and regulatory authorities. The main and most prominent question is whether the growing participation of high-frequency traders is beneficial or harmful to financial markets and their participants. Also different stakeholders are considered HFT strategies, profitability and subsequently needed regulations. So, research papers in this context focus either on different market characteristics and their relationships with HFT such as liquidity, volatility, efficiency, fairness and co-location, investor costs, or HFT itself by analyzing HFT strategies, costs and profitability and performance.

Researchers have used different approaches and methods in their analysis and there is evidence of mixed results about the same features. Some argue HFTs improve liquidity, enhance efficiency and reduce volatility, while others concern that HFT make worse volatility, and with predatory activities profit at the expense of other investors. The latter has been much under consideration after “flash crash” in May 10, 2010 in the U.S.

There are different types of question in the literature regarding HFT activities in the markets. Is HFT beneficial or detrimental to the markets? What are strategies used in HFT, their profitability and finally regulations regarding HFT? More specifically, how does HFT influence the market quality? (Volatility, liquidity, price discovery) What are the needs for a HFT regulation?

The rest of this paper is organized as follows. The next section provides different descriptions of HFT that is used in the literature. I then review the impact of HFT on

different attributes of market quality in section 3. Section 4 reviews HFT strategies, profitability and performance. I then review regulatory issues related to HFT in section 5. I provide concluding remarks in section 6.

2. HFT definitions

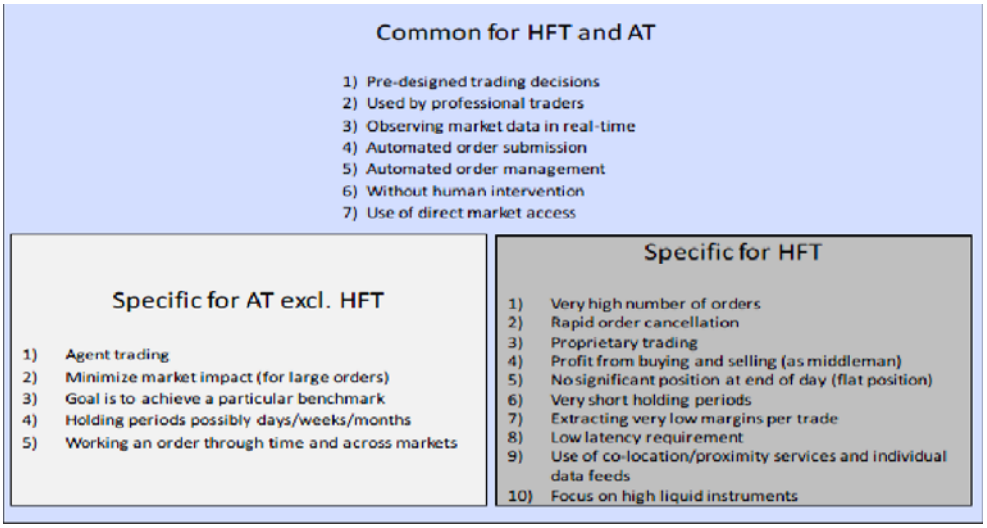
While there is a formal definition for high-frequency traders in U.S. Securities and Exchange Commission (SEC) (2010, p. 45) : "professional traders acting in a proprietary capacity that engage in strategies that generate a large number of trades on a daily basis", but in academic literature there is no clear definition for this type of trading. While there are different definitions for distinguishing HFT from non-HFT traders but there are some general agreements related to HFT features as well: automation of trading process, high speed of receiving information and submitting orders, and generation of huge amount of messages.

Since HFT is not a clearly defined term in literature, researchers have used and sometimes made their definitions and proxies of HFT based on the dataset they have applied. For instance, Zhang (2010) in a broad definition defines HFT as all-short term trading activities of institutional investors that are not covered in the form of 13F. Kirilenko et al. (2014) define high-frequency traders as any market participants with extremely high trading volume and well balanced inventory. Conrad et al. (2015) proposes a high-frequency quoting activity measure, which is measured as the number of changes at best bids and asks and of depths at inside quotes. Hasbrouck and Saar (2013) estimate "strategic run," which is a "series of submissions, cancellations, and executions that are linked by direction, size, and timing, and which are likely to arise from a single

algorithm" (p. 660). However, as U.S. Securities and Exchange Commission (SEC) (2014) cautions, using proxies developed from datasets naturally comes with a danger of including algorithmic and computer-assisted trading activities that are not HFT in the scope of research. Other researchers have used datasets that are designed specifically to examine the consequence of HFT activities but as Conrad et al. (2015) contend, data are limited to specific exchanges. So using such datasets for systematic investigation are not appropriate particularly in the fragmented markets such as U.S. Clark-Joseph (2013), Baron et al. (2014), and

Kirilenko et al. (2014) classify a trading account as a high-frequency trader if its trading volume is relatively high but end-of-day inventory position is low compared to its trading volume. Jarnecic et al. (2014) defines HFT as the use of high-speed computer algorithms to automatically generate and execute trading decisions for the specific purpose of making returns on proprietary capital. Cvitani et al. (2010) mention that HFT typically refers to trading activity that employs extremely fast automated programs for generating, routing, canceling, and executing orders in electronic markets.

Although there is not a unique definition for HFT among scholars but Gomber et al. (2011) provides distinguishable characteristics of HFT in comparison with general algorithmic trading (AT).



Characteristics of HFT and algorithmic trading (AT)

Adapted from Gomber et al. (2011)

3. HFT and market quality

Given the speed of technological progress and used strategies of high-frequency traders, it is so important for researchers, market regulators, investors to find out whether such innovations influence market quality. If speed advantage of high-frequency traders is merely considered as an informational advantage, HFT is only another form of informed trading that improves the price discovery (Kyle, 1985). However, high-frequency traders may use such speed advantage in the cost of other market participants. According to Harris (2013), HFT can be in three forms: valuable, harmful, very harmful; these are decline in transaction costs, take advantage of new information and use of limit orders of low speed traders, anticipation in order flows and front-run them or engage in quote matching respectively.

My review of literature indicates that HFT can be helpful in improving market quality. Although there are some opposite studies, but most of academic literature suggest that

spreads and volatility declined and price efficiency increased during normal market conditions. However, one open research area is this realm is the impacts of HFT during times of high market volatility. All in all, one thing is clear is that market failures and extreme volatilities existed before existence of HFT.

Putting aside some exceptions, scholars have found that HFT decrease spreads. Jovanovic and Menkveld (2015) analyzed HFT activities in Dutch equity market and found that passive HFT decreases effective spreads. Stoll (2014) found that the HFT is associated with lower spreads. Bershova and Rakhlin (2013) by using datasets from Tokyo and London show that there is negative relationship between HFT activities and bid-ask spreads. Boehmer et al. (2015) analyze 42 equity markets and reports a decrease in effective spreads for 69% of the markets after introduction of colocation services. Riordan and Strokenmaier (2012) analyze 98 stocks listed on Deutsche Boerse's HDAX segment and reveal that after technological upgrade effective spreads decreases.

However, there are some opposite findings as well. Lee (2015) after assessing KOSPI 200, Korean index futures market, shows that HFT activities generally do not increase liquidity or improve market quality. Gai et al. (2013) assess the effect of two technological upgrades on NASDAQ and conclude that there are not significant effects on quoted and effective spreads. Brogaard et al. (2014b) show that HFT activities increased spreads.

There are also researches in literature about HFT activities impact on price efficiency. Brogaard et al. (2013) find that aggressive HFT tend to the direction of permanent changes opposite the direction of transitory movements, hence improving price efficiency. Carrion (2013) explains that price efficiency has positive association with

HFT aggressiveness. Conrad et al. (2015) show that HFT are positively associated with price efficiency. Chaboud et al. (2014) analysis on forex market shows that algorithmic trading increases price efficiency.

Hagstomer and Nordén(2013) analysis on NASDAQ OMX Stockholm Equities market show that HFT market making, statistical arbitrage and momentum strategies all mitigate intraday price volatility. Hasbrouck and Saar (2013) examined full NASDAQ order book and find that Low latency automated trading was associated with lower quoted and effective spreads, lower volatility and greater liquidity. Weisberger and Rosa (2013) analyze U.S. Equities and CBOE VIX data and mention that there is no evidence that volatility has increased due to recent market structure changes. Bollen and Whaley (2015) examined futures markets and say volatility attributable to structural factors did not change in Most of these contracts over long time periods, suggesting HFT and automated trading Have not impacted volatility. Debelle (2011) analyzes various FX venues, notably Reuters and EBS, and show that HFT is beneficial during normal market periods, with similar behavior to traditional market participants during high volatility periods.

4. HFT strategies and profitability

There is not systematic information on the major players in the realm of HFT. Diversity of market participants using HFT platforms and technologies is actually high. High-frequency traders are from different domains such as proprietary trading firms, broker-dealer market makers, HFT boutiques, quantitative hedge funds that leveraging HFT technology in order to increase profits (Easthope and Lee 2009).

Since HFT strategies are diverse and opaque to name them all, some assume they are highly different from well-known strategies. But, some of these strategies have been in the market for years and are not necessarily new. Difference is that some of them are equipped with technology arms which allow them to be more profitable. May be we can say that HFT is a means to use specific trading strategies rather than strategy in itself. Gomber et al. (2011) depict different types of HFT strategies in a chart as below:

Common HFT strategies

Adapted from Gomber et al. (2011)

One of the most common strategies in HFT is liquidity provision. In this strategy HFTs act as market makers. They earn profit from this strategy in two forms: earn the spread of bid-ask by providing liquidity and receive rebates or reduced transaction fees from trading venues. Another common strategy among HFTs is “statistical arbitrage”. In this strategy they don’t make profit on a single asset but from discrepancies among multiples assets and exchanges. They actually do arbitrage in the same as past but since arbitrage opportunities are short-lived and they are equipped by state of the art technology it’s possible for them to earn on this opportunities. In this type of strategy since the react to market inefficiencies, they are liquidity takers. One sub-class of this type of strategy is

“market neutral” arbitrage. Arbitrageurs try to take long positions in some securities while simultaneously shorting others. Since the securities are closely correlated or in more technical meaning closely “cointegrated” up and down movements of the general market does not affect overall positions. Profit from this strategy comes from the difference between assets (technically spread). Since this strategy provide protection against overall market movements is highly attractive for HFTs. Moreover, this strategy is not necessarily applied only in one type of asset class. It also could be executed in the cross-asset, cross-market and ETF forms. For instance, increasing fragmentation among exchanges give provide this opportunity for arbitrageurs to trade and gain profits from the discrepancies between different markets.

Another type of HFT strategies is liquidity detection. In this strategy HFTs try to decode the patterns of market participants in particular in limit order books or dark pools and adjust their actions accordingly. These liquidity detectors that gather information about algorithmic traders are frequently referred to as “sniffing out” other algorithms. (ASIC 2010a) Another kind of strategy among others that is possible to use for HFTs is the high speed “quote matching” explained by Harris (2003). In this strategy, high-frequency trader who has detected a large order within the limit order book by using high speed computers and algorithms places his order ahead of that. For example, if it’s a large buy order, he opens his position of buy at a slightly higher limit. When price goes up, he makes profit from the rise. On the other hand, if price goes down, the existence of large order in the order book serves as a hedge against which the trader can liquidate his position, therefore limiting his losses.

Another type of possible arbitrage strategy of HFTs is based on their faster access to market data. This form of arbitrage that HFTs are able to see new market information before many market participants is called “latency arbitrage”. Theses HFTs have high speed access to data feeds and co-located their servers close to exchanges to decrease the latency. For instance, some argue that in the U.S. while there is a national best bid and offer (NBBO) act, these HFTs are able to profit from their speed advantage. (see e.g. Gaffen 2009). But there are not so many researches in the literature regarding this type of rules and traders in other parts of the world such as Europe and Asia.

Momentum strategies especially in short term is another type of strategy used by HFTs. This strategy is not actually new to the market and classic day traders used it a lot as well. Unlike earlier mentioned strategies in this kind HFTs don’t try to provide liquidity or make profit from discrepancies. They trade aggressively to earn from market movements/trends.

All in all, maybe we can say that HFT itself is not a strategy but its application of new and complicated technology that enable to execute traditional trading strategies in other forms.

Regarding profitability of HFTs there are different studies in the literature about profitability of HFTs and they show that HFTs are profitable. Baron et al. (2014) using transaction level data with user identifications show that HFT is highly profitable. They report that HFTs totally earn over $23 million in trading E-mini S&P 500 futures contract during the month of August, 2010. They show that these profits come from different type of traders such as opportunistic, fundamental (institutional), small (retail), and non-HFT market makers. They also estimated that median Sharpe ratio across firms in August 2010

was 4.5 which is unusually high average. They assert that unlike hedge funds (Carhart, 1997), but consistent with some of the literature on hedge funds (Jagannathan, Malakhov, and Novikov, 2010), HFTs consistently outperform the market. Brogaard (2010) using NASDAQ dataset estimates HFTs gross return to be approximately $2.8 billion annually and gaining a Sharpe ration of 4.5. Kearns et al (2010) estimate an upper level for the profitability of HFT. Although this study only covers aggressive orders, the result is approximately in line with Brogaard (2010). Their estimation is a possible profit of $3.4 billion in 2008. This is assumed as an upper limit for HFT and they argue that this is a huge overestimation because they do not consider fees. One of well-known Wall Street HFTs called Traderworx (2010a) estimated a slightly lower estimation of $2 billion annually.

5. HFT and regulations

HFT discussions have become widespread among market participants, policy makers, and academics. Since HFT is actually a new phenomenon in the realm of financial markets, regulators are trying to keep in pace with technology and make decisions that are necessary if HFTs prove to induce risk to the quality and integrity of markets. Although there are not any unanimity among people regarding benefits of HFT to the markets and while most of the literature has a positive view about HFT activities, number of laws have been introduced around the world to discourage these activities.

Ait-Sahalia and Saglam (2014) estimate that financial transaction taxes (FTT) as a discouraging proposal does not improve liquidity. They assert minimum resting times and order cancellation fees result in enhanced liquidity when market conditions are normal,

although liquidity dissipates rapidly when the market is highly volatile, hence failing to induce high-frequency traders to supply liquidity when it is most needed. Matheson (2011) contends that FTTs are unlikely to decrease the risk of bubbles given a lack of "convincing evidence" (p. 37) that FTTs reduce short-term volatility. Colliard and Hoffmann (2015) show that the French FTT had a negative effect on French market quality after the implementation of the tax legislation. They find that although spreads, intraday price range, and volatility are generally not highly affected by the French FFT, stock with no market making activities by HFTs have experienced a decrease in liquidity. Becchetti et al. (2013) find that although trading volume has decreased significantly after introduction of the FTT in the French stock market, liquidity has not been impacted significantly. Also, intraday volatility has decreased significantly. Capelle-Blancard and Havrylchyk (2014) report that the French FTT did not impact market volatility or liquidity, as measured by the bid-ask spread. Gomber et al (2015) after analyzing equity market data from the CAC 40 index show that liquidity has declined after the French FTT, as relative spreads of the largest companies rose by 12%. Results of Meyer et al (2013) also indicate that the French FTT have deteriorated market quality. Capelle-Blancard (2014) analyzing Italian market after the introduction of FFT in March 2013 show that The author finds that the overall market quality decreased slightly after the initial introduction of the Italian FTT, but the effect was reversed when the FTT was extended to the derivatives later in 2013. The U.S. is also considering ways of implementing its version of FTT.

One of the major characteristics of HFTs is the high rate of order submission and cancellation. Market regulators have considered charging a fee for traders with high

order-to-trade ratio (OTR) to scale down harmful behaviors of HFT firms. But some studies show opposite results. van Kervel (2015) assert that implementation of a cancellation fee on OTR traders will discourage competition across venues that leads to decline in market liquidity. Caivano et al. (2012) and Friederich and Payne (2015) show that introduction of the Italian OTR fee structure resulted in lower average Italian OTRs. Friederich and Payne (2015) indicate that these fees has had a negative effect on market quality. On contrast, Capelle-Blancard (2014) and Colliard and Hoffmann (2015) respectively in Italian and French markets find that OTR fee did not have any significant effect on market quality. Haferkorn and Zimmermann (2014) show that the introduction of German HFT Act in 2013 resulted in decline in the number of orders, while the number of executed trades showed little change. They also indicate that relative spreads rose while the overall effect is negligible. Haferkorn (2015) argue that price dispersion between trading venues has increased after German HFT Act, means the market efficiency has improved due to the act.

Another issue about HFTs is “minimum order resting time”. Given the tendency of HFT to send and instantly cancel orders, this measure can be used to force all orders to stay in the market at least for some time periods. Foresight (2012) and Jones (2013) contend that mandating this measure will crush the proliferation of flashing orders. However, they say that market participants will be discouraged to submit limit orders given the inability to cancel their orders before the required minimum resting time periods pass.

In addition, to neutralize the technology arms race and the winner-takes-all nature of some HFT strategies, researchers have proposed implementing random delays in processing of orders by certain milliseconds. For instance, Harris (2013) argues that

messages sent by a trader with a millisecond advantage over another will out-turn those by a slower trader only 59.5% of the time if all messages are delayed randomly by 0 to 10 milliseconds. Hasbrouck (2015) shows that the advantage of high speed traders declines significantly under random delays. This way discourages HFTs from engaging in a fruitless arms race.

6. Conclusion

Technology innovations in the form of high speed computers and network capacity have highly impacted the landscape of financial markets. In today's markets, most of the trade volume are handled by high speed and sophisticated algorithms. Networked computers and algorithms are involved in different parts of trade implementation such as strategy back-testing, data feeding, and execution. High-frequency trading firms rely on technology because through that they have the capability of quick reaction and liquidating all positions at the end of day. Different types of HFT strategies have different impact on markets. Also some argue that this kind of trading could be the main reason behind higher market volatility although academic researches mostly don't accept this argument. While the most of academic literature show the positive impacts of HFT for market quality (measured in terms of lower spreads, faster execution, better informational efficiency), there are many people who concern about the proliferation of HFT. They argue that for those traders (e.g. retail traders) who don't have access to such technologies used by HFTs the market is not really fair and they cannot compete with high speed traders. If so, this realm should come under concise scrutiny of regulations. On the other hand, since the large portion of trades and quotes are made by algorithms,

the proliferation of HFTs may decrease or eliminate certain market anomalies that are due to human emotional biases, such as fear, greed, regret.

All in all, high-frequency trading literature could be concluded by following remarks:

- HFT is new ways of implementing traditional strategies but speed is crucial.
- HFT is actually related to market structures and more fragmentation may induce some other issues in the future.
- Academic literature mostly shows positive impacts of HFT on different market quality metrics.
- Researches about volatility in the literature have a mix results and more research on the effects of HFTs on volatility under normal and high volatile markets is beneficial.
- Regulators should consider negative and positive effects of their HFT rules about overall market quality.
- There is a need for transparency and open communication to assure confidence and trust in financial markets.

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