

NORGES HANDELSHØYSKOLE

The Significance of High Frequency Trading on Financial Markets

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Term Paper

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Executive Summary

Within the last two decades, high frequency trading (HFT) has been a significant type of trading distinguished as having high turnover rates that has dramatically changed the way financial markets traditionally operated. In this paper, we examine the main issues that surround HFT in today's world. We have found three main issues, and explained its significance in HFT. Firstly, HFT has a tendency to either reduce volatility in the financial markets, or not affect volatility at all. Secondly, we concluded that co-location has resulted in an overall improvement to the liquidity of futures contracts. Thirdly, there is a conclusion, although not strong, that unethical issues surround HFT, since the motive of HFT is to make profit for yourself, regardless of whether you are producing any value added for others. In the next section, we analyse the issues unaddressed in the studies that we have consulted, questioning some of the assumptions and research parameters implicit in our paper. We then identify future research directions that could be considered for a more comprehensive understanding of our three main issues of HFT identified. We recommend that the research scope should include other regions, such as Asia, where HFT is prevalent as well. Also, the assumption of whether co-location truly benefits the financial markets must be further studied. Finally, more ethical frames must be employed to assess the ethics of HFT. With these recommendations, a greater insight into HFT can be reached, which will provide markets with a clearer understanding on HFT's impact and significance on the financial markets.

Content page

1. **Introduction**
   - 1.1. Definitions of HFT
   - 1.2. Factors that led to HFT
   - 1.3. Related concepts
   - 1.4. Objective of the paper

2. **Strategies**
   - 2.1. Market making
   - 2.2. Arbitrage
   - 2.3. Liquidity detection
   - 2.4. Order properties strategies
   - 2.5. Momentum ignition
   - 2.6. Evaluation of strategies

3. **Other issues**
   - 3.1. Risk of increased volatility
   - 3.2. Flash Crash
   - 3.3. Regulations

4. **Review of Research Literature**
   - 4.1. Impact on Market Quality
   - 4.2. Co-location
   - 4.3. Ethics

5. **Insights and recommendations for future HFT research**
   - 5.1. HFT in Asian Markets
   - 5.2. Co-location and liquidity
   - 5.3. Ethics in HFT
   - 5.4. Summary of insights and recommendations

6. **Conclusion**

7. **Bibliography**

1. Introduction

1.1. Definition of High Frequency Trading

As more incentives are offered to companies for adding liquidity into the financial markets, the high frequency trading (HFT) approach has become increasingly popular. HFT relates to an automated trading platform where computers are programed to transact voluminous orders at a fast speed. This efficient method is achieved using complex algorithms to analyse many markets simultaneously before executing the orders based on current market conditions. Typically, traders with the fastest execution speed will earn the highest profits from the market.

The U.S. Securities and Exchanges Commission (SEC) attributed certain characteristics to HFT which includes using advanced computer programs to execute orders, having co-location servers to minimise network and latencies, having high turnover of small positions and maintaining minimal overnight positions.

1.2. Factors that led to HFT

Technological advancements in trading was the main driving force behind HFT. With the adoption of modern technology, manual trading of commodities in the early 18th century evolved into electronic trading of securities after the introduction of Electronic Commodities Networks in the 1990s. In addition, the authorisation of electronic exchange by SEC in 1998 provided the platform for HFT to be executed.

Besides technological advancements, bid-ask spreads also narrowed in 2001 as the US stock exchange started quoting prices in decimals instead of fractions. This promoted the use of algorithmic trading as traders had to seek better alternatives to profit from the narrowed spread.

In addition, the Regulation National Market System imposed by SEC promoted the transparency and competition between markets and required trade orders to be posted nationally. Thus, traders could earn arbitrage profit from differential pricing between two exchanges. Traders had to execute orders at high speed to benefit from the temporary difference in pricing which could be achieved through high frequency trading.

Technological advancement in stock markets, narrowing bid-ask spreads and regulatory change are the main factors that contributed to the rise of high frequency trading.

1.3. Related Concepts

This section aims to highlight the distinguishing factors and relationship between the three closely linked concepts – algorithmic trading, HFT and automated trading.

Algorithmic trading uses the built-in algorithm in computer systems to analyse market data and other information at a high frequency. The aim is to achieve a good price based on pre-defined

benchmarks while moderating the trading market aggressiveness. To minimise the impact of trading, algorithmic trading may involve agent trading where customers hold on to securities over long periods of time.

Similar to algorithmic trading, HFT also involves pre-designed trading decisions and automated order submissions and executions. The main distinction is that algorithmic trading seeks to minimise market impact for large orders relative to a pre-defined benchmark through agent trading while HFT mainly focuses on proprietary trading. As such, HFT can be considered as a subset of algorithmic trading.

Automated trading is the complete automation of the quantitative trading process from order creation, order submission to order execution. In order to determine the time the trade will close and conduct portfolio risk assessment, automated trading would require quantitative representation such as quantitative modelling, indicative tracking and monitoring portfolio risk as well as algorithmic trading.

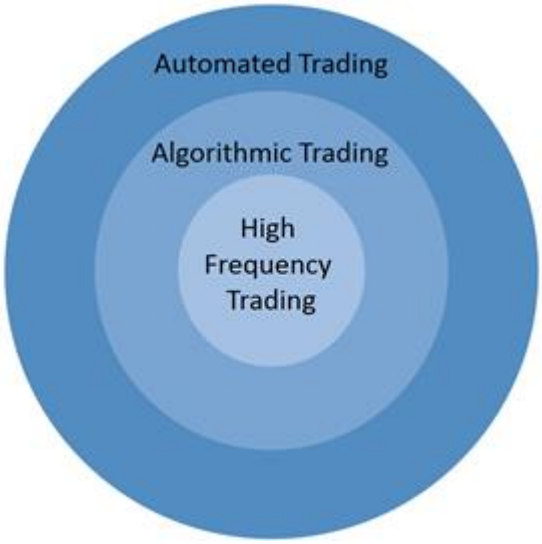


Figure 1: Relationship between HFT, algorithmic trading and automated trading

As illustrated in Figure 1, HFT is a subset of algorithmic trading which is encapsulated in automated trading. As automated trading is a very broad topic where HFT is one of the divisions, the scope of the paper will focus on providing an in-depth analysis of issues concerning high frequency trading.

1.4. Objective of the paper

This paper aims to provide background information and an in-depth analysis on the rising trend towards HFT. The remainder of the paper has been structured in a manner that will guide readers to critically evaluate the proliferation of HFT and eventually make an informed decision if HFT is their optimal trading strategy.

The paper will begin with a discussion on the common HFT strategies in Section 2. Section 3 goes on to highlights other concerns of HFT such as the risks and regulations through a case study of the Flash Crash in 2010. In addition, academic literature and journals regarding selected significant issues in HFT will be addressed in Section 4. Finally, our own insights and proposed future research directions will supplement the literature review in Section 5.

2. Strategies

HFT uses advanced technology to implement traditional trading strategies more efficiently and effectively. Traders adopt many strategies to earn profits through HFT, where each strategy has their own risk and complexities. In this section, we will evaluate the more popular strategies which include market making, various types of arbitrage, liquidity detection, order properties strategies and momentum trading.

2.1. Market Making

The market making strategy, which is the most common HFT strategy, enables a trader to earn from the bid-ask spread. A market maker is a firm that is willing to trade a certain stock regularly and continuously at the quoted price on the stock exchange. Hence, the market making strategy involves programming an algorithm that will automatically execute limit orders to sell slightly above the current market price and buy slightly below the current market price, enabling the trader to make a profit.

2.2. Arbitrage

Arbitrage is a very common strategy used by high frequency traders as the system allows traders to execute orders immediately to capture the value of any momentary pricing inconsistencies across different exchanges and assets. The strategies discussed in this section include statistical arbitrage, event arbitrage, index arbitrage and latency arbitrage.

One of the most common type of arbitrage is *statistical arbitrage* which occurs when traders exploit the temporary differential between correlated securities and the underlying stock . Another variation of this strategy is in the form of *event arbitrage* which is a result of recurring events generating predictable short term responses and traders can benefit by predicting such responses. Apart from statistical and event arbitrage, *index arbitrage* can also occur when the traders gain access to information on the decrease in prices of securities in the index tracker funds before trackers are aware of the price change. These traders will buy the securities in advance of the trackers and resell the securities to the index tracker funds for a profit. The last type of arbitrage discussed in this paper is *latency arbitrage* where the advantage of having faster access to data in the financial markets allows traders to interpret and act on new market information before other market participants. Such a practice is often termed ‘predatory’ as these traders benefit at the expense of other market participants due to their unfair advantage.

2.3. Liquidity detection

Liquidity detection involves analysing the order patterns of other market participants so that the high frequency traders can plan their actions accordingly. Liquidity detectors employ various strategies to detect orders submitted by execution algorithms or attain information about electronic limit order books. For example, some liquidity detectors “sniff out’ the execution algorithm by gathering information about algorithmic traders.(Gomber, Arndt, Lutat, & Uhle, n.d.). Other detectors ‘ping’ or ‘snipe’ in order books or dark pools to retrieve information

Another type of liquidity detection strategy is quote matching whereby a trader who detects a large order within the order book creates an order to put ahead of the large order. If it is a large buy order, the trader will price his buy order slightly higher than the large order. If the prices increase, he will earn additional profits. On the other hand, if prices were to fall, the large order book limits the trader’s losses as it acts as an option against which the trader can sell his own shares.

2.4. Order properties strategies

Order properties strategies uses the algorithmic analysis of market properties to ascertain if the stock is underpriced. Some examples of the properties include the age of an order or size of displayed orders. Tracking important order properties will enable the trader to accurately predict the future price of the stock and the trader can plan his optimal trading strategy.

2.5. Momentum ignition

Momentum ignition strategy involves initiating and cancelling trades of a stock in a particular direction to ignite a rapid market price movement. The submission and cancellation of orders can be picked up by other traders’ algorithm and trigger them to trade the stock. As such, the firm initiating and cancelling the trade can profit by leveraging on the subsequent price movements.

2.6. Evaluation of strategies

Proponents of HFT believe that the stock exchanges have greatly benefited from the increased efficiency in the price formation process and additional liquidity contributed through HFT strategies. On the other hand, opponents of HFT debunk this argument as they argue HFT strategies will result in unequal opportunities between market players and create the possibility of market abuse which will erode market integrity and investor confidence.

With technological advancement in the markets, new HFT strategies are likely to be introduced in the future which will result in additional benefits and risks. As such, to derive the optimal outcome from HFT, it is important to take advantage of the benefits while mitigating the risk.

3. Other issues

This section will address the concerns of the increased volatility due to HFT which is reflected in the 6 May 2012 Flash Crash. The policies and regulations implemented to tackle this problem will then be evaluated.

3.1. Risk of increased volatility

One major criticism of high frequency trading is that it increases market volatility. Market making strategy helps to increase market liquidity and pricing under calm market conditions but results in increased volatility during periods of high market uncertainty (Yale School of Management, 2011). When the market is highly volatile, these market makers will pull out of the market due to the uncertainty which further reduces the liquidity in the market and reinforces the volatility in the market. In extreme cases, this could lead to flash events.

3.2. Flash Crash

The flash crash that occurred on 6 May 2012 proved that the danger from the enhanced volatility caused by HFT should not be undermined. SEC and the Commodity Trading Commission (CFTC) issued a joint report that concluded the responses of HFT firms contributed to the volatility during the dramatic stock market crash. This resulted in an exchange of 2 billion shares worth $56 billion and nearly 1,000 points dive in share prices in just one day. (U.S. Securities & Exchange Commission, 2010)

The flash crash was instigated by a U.S. mutual fund, Waddell & Reed Financial, that had used an automated algorithm trading strategy to sell contracts known as e-minis. The $4.1 billion sell order was the largest change in the daily position of any investor in 2010 and triggered other traders, including high frequency traders, to sell e-minis (Treanor, 2015). This resulted in a “hot potato” effect as high frequency traders started to buy and resell the e-mini contracts to one another, which generated high volume but little liquidity in the market. In addition, the volatile share prices caused automated trading systems to be deactivated as the system was programmed to pause when share price moved beyond certain boundaries. Without the automated trading systems, liquidity levels dropped even further as many traders either withdrew from the market or manually traded in small volumes.

This reinforces the danger of the increase volatility generated by HFT which can inhibit trades by other market participants and potentially spiral into a financial crisis.

3.3. Regulations

In view of risk and unfairness pertaining to HFT, there is immense pressure on the authorities to enforce regulations to mitigate the impact of the risk and prevent a catastrophe, such as a flash crash, from unfolding.

It is requirement that all HFT firms need to be authorised under regulatory framework for the provision of investment services in the Market in Financial Instrument Derivatives (MiFID) in 2007 (European Commission, 2016). The MiFID regulation established market making agreements, limits on the number of order messages and minimum tick sizes to mitigate the risk of market abuse in HFT. In 2014, the European Parliament introduced MiFID II with updated rules for financial markets and securities.

In addition, to provide greater assurance of the integrity of European financial markets and investor protection, the Market Abuse Directive and Regulation (MAD/MAR) was introduced to ensure a level playing field for all market participants. Some MAR indicators are designed to specifically target the unethical market manipulation strategies used in HFT. For example, MAR prohibits firms from creating orders that disrupt the functioning of the financial system, overloading orders which will make it difficult to identify genuine orders and creating misleading trends through the momentum ignition strategy in HFT.

With regards to HFT regulations, there is a trade-off between protecting market participants by implementing additional regulation and losing potential investors due to the inflexibility brought by the strict regulations. As such, authorities must constantly review the policies to ensure it remain relevant to the dynamic markets conditions and deliver the optimal outcome for all market participants.

4. Review of Research Literature

HFT is a relatively fresh concept in the financial markets of today. It first took place in 1999 (Haldane, 2010), but until recently, high-frequency trading was a little-known topic outside the financial sector, with an article published by the *New York Times* in July 2009 being one of the first to bring the subject to the public's attention (Duhigg, 2009). The research studies consulted in this paper address three main issues: 1. The impact of HFT on market quality; 2. The fairness and impact of co-location in HFT; and 3. The ethical issues of HFT.

4.1. Impact on Market Quality

The advent of (HFT) has brought about significant impacts on the quality of the market it operates in. Market quality refers to liquidity, price discovery, and volatility (Brogaard, 2010). According to Gomber, P., theoretical models that address the impact that HFT has on market quality can be found in various research articles, such as Cvitanic and Kirilenko (2010), whereby they model an electronic market populated by low-frequency traders (humans) and then add a high frequency trader (machine) (Gomber, P.).

According to Gomber, P.:

> *"Cvitanic and Kirilenko (2010) find that the presence of the high frequency trader is likely to change the average transaction price and the distribution of transaction prices as a whole. Particularly, they show that the transaction prices are more concentrated around the mean (i.e. have lower volatility) and they find an improvement of forecastability of transaction prices. "*

Another academic literature, "High Frequency Trading and its Impact on Market Quality" by Brogaard, (2010), confirm this. In measuring HFT Liquidity, Brogaard studied the descriptive statistics of how HFT demand liquidity, following which, he examines how they supply it. Finally, he analyses how much liquidity they provide in the quotes and the book, not just for trades (Brogaard, 2010). Also, he analysed how HFT affects the market quality through volatility. By constructing a hypothetical alternative price path that removes HFTs from the market, he shows that the volatility of stocks is roughly unchanged when HFT initiated trades are eliminated and significantly higher when all types of HFT trades are removed (Brogaard, 2010). He first uses a regression model to observe whether any relationship between volatility and HFT exists. Next, he compares the price path of stocks with and without HFT being part of the data generation process (Brogaard, 2010). His findings are as follows: 1. HFT and volatility are not highly related; 2. HFT reduces volatility to a considerable degree. His conclusion is that "HFT activity either has no impact on volatility or tends to decrease it."

This agreement in analyses between various authors of research articles examining the impact of HFT on market quality shows that the critical evaluations are accurate and precise. In other words, the majority of papers examining this effect of HFT agree that indicators of market quality tend to be increasing, such as liquidity, and lower volatility in both the short and long term. Furthermore, the fact that different methods of analysis lead to the same conclusion is proof that the hypotheses being tested are positive. Perhaps more could be done to ensure the consistency of the findings, such as having extended lengths of study (into the future) as HFT is only a relatively new occurrence. Results from the past may not be indicative of trends in the future, and what lies in the future, remain to be seen. Our view is further supported by another academic literature, "High Frequency Trading - An Asset Manager's Perspective" by Norges Bank Investment Management (2013), where it is stated that there is still a lack of consensus for an appropriate framework to measure market quality and that more empirical and theoretical work on this area is needed.

4.2. Co-location

Co-location is defined as “High-frequency traders placing trading computers in data centres that house exchange’s computer servers”, which is “made available by stock exchanges, which charge fees for services offered, building new revenues.” (Kauffman, 2015). Regarding Co-location services, there are two main issues addressed. Firstly, it is about the issue of fairness. Secondly, it is about whether the introduction of co-location enhances liquidity.

According to Gomber, P.:

> *“As mentioned before, the discussion about HFT is closely related to the issue of fairness. This is due to the fact that high frequency traders need low latency access, which gives them a speed advantage compared to other traders. This private advantage of preferred access is neither new nor introduced by the occurrence of HFT. Hasbrouck and Saar (2010) admit that co-located traders have a significant timing advantage and that floor traders had a timing advantage over off-floor traders in the same manner. “*

In his paper, he notes that many research articles address fairness issues only theoretically but hardly list the exact terms for co-location to be “fairer” (Gomber, P.), such as “possible number of accesses, number of participants, pricing schemes etc.” which might indicate that there is a lack of transparency, which prevents comparison of access conditions between marketplaces (Gomber, P.).

In the article “The Impact of Co-Location of Securities Exchanges’ and Traders’ Computer Servers on Market Liquidity” (Frino, Mollica, Webb, 2013), they address the impact of co-location on whether it enhances liquidity of futures contracts. In their findings, there is “strong evidence” of a decrease in bid-ask spreads and an “increase in market depth after the introduction of co-location.” (Frino, Mollica, Webb, 2013). They eventually conclude that the introduction of co-location has resulted in an overall improvement in the liquidity of futures contracts.

Co-location is only possible due to the advancement of technology. With the rapid progression of science and technology, and mankind’s desire to seek new, and more efficient, ways of trading, it will be no surprise if, in the future, the notion of co-location becomes ubiquitous, thereby mitigating the issue of fairness. Perhaps, co-location would evolve into something far more advanced that it is today, providing even more liquidity in the stock exchanges. However, the issue of fairness is unlikely to dissipate, as society can hardly ever be equal. There will always be a portion of traders with the speed advantage (over others) and other advantages associated with co-location that others are deprived of. However, this gives rise to many ethical issues. Can the unfairness in co-location be offset by the many advantages it brings about, such as increasing liquidity of financial markets? This, perhaps, needs to be studied in greater detail for any conclusive statements to be made.

4.3. Ethics

Finally, the issue of ethics is another main point of contention with respect to HFT. Laure Madonna's (2013) article, "The Ethics of High Frequency Trading", looks at the cloud of controversy about its negative impact on financial markets that HFT is under. In her article, she analyses the ethics of HFT from two points of view, namely, consequentialism, and deontological ethics. In consequentialism, the consequences of one's conduct are the ultimate basis for any judgment about the rightness of that conduct. Thus, from a consequentialist standpoint, a morally right act (or omission) is one that will produce a good outcome or consequence (Madonna, 2013). In deontological ethics, the morality of an action is judged based on the action's adherence to a rule or rules. It is sometimes described as duty, obligation, or rule-based ethics (Madonna, 2013).

According to her:

> *"There are no rules against high-frequency trading, but deontological principals (sic) forbid lying or cheating. According to former Wall Street insider Haim Bodek:*
>
> *We're cheating. Didn't you know? Everyone knew. HFT trading is predatory, it's disruptive to markets, and it is actually unbeatable without regulatory change. I don't think anybody can compete that's outside of this particular practice, and that's why it's 50 to 70 percent of U.S. market because the diversity of our algorithmic trading tradition have been annihilated by this particular practice."*

All HFT traders are working for their own account and not for any clients, which implies that the motive of HFT is to make profit for yourself, regardless of whether you are producing any value added for others (Madonna, 2013). In contrast, someone who is virtuous will not partake in activities simply for the money, without giving anything to society in return. As HFT is essentially automated, it has a lack of concern for the improvement of society. Madonna (2013) concludes that although HFT strategies have been demonstrated to be unethical, their strategies need further detailed and empirical study before any final conclusions can be drawn (Madonna, 2013).

The articles researched in this paper have looked at ethics from two main approaches, namely, consequentialism, and deontological ethics. However, there exists other ethical frameworks that can possibly be used to analyse the morality behind HFT. As with all other automated operations, HFT lacks the human touch and emotion, which makes the issue of ethics ever so important in the financial markets today.

5. Insights and recommendations for future HFT research

Considering the points mentioned in our review of existing literature, we realized that the studies of HFT previously done could be further expanded with the objective to provide better support and legitimacy of proof for the hypotheses and conclusions obtained from those previous studies.

This subsection therefore provides insights on specific areas that subsequent HFT studies can be done on, which will aid in guiding the research direction of HFT in the future.

5.1. HFT in Asian markets

From subsection 4.1, existing studies on HFT have shown that HFT has a positive impact on market quality. However, the consistency of findings has room for improvement due to HFT being a relatively new occurrence in financial markets. To increase consistency of findings, while having extended lengths of study is plausible, presently it is difficult to do so as HFT is a new phenomenon and as such, existing data available is not sufficient to conduct a study of extended length. However, what can be done presently is to increase the scope of study of HFT. When reviewing existing literature on HFT, we realized that most, if not all, of the literature works cited in this paper obtained data from US and Europe markets. To exemplify this, in subsection 4.1, Brogaard (2010) and Gomber, P both used either market information from US or Europe, or both.

The dominant use of only US and Europe market information has shown that there is a lack of research and analysis done on other markets around the world, such as Asian markets. However, referring to Figure 2 below, the market capitalization of Asian markets constitutes a significant 33.3% of the global total market capitalization (Desjardins, 2016), which shows the high significance and impact that research on Asian markets can have.

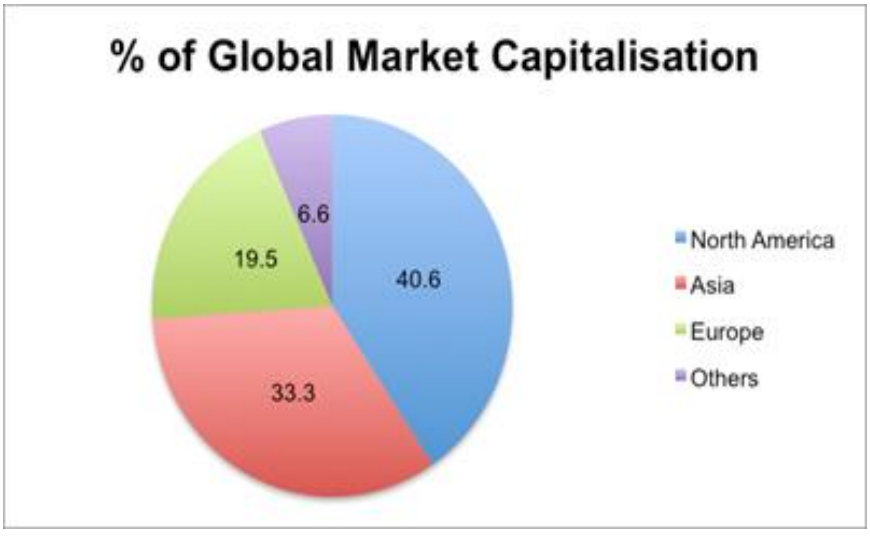


Figure 2. Percentage of global market capitalisation by continent

Furthermore, while most Asian markets have been slow to hop on the HFT bandwagon, where HFT accounted for only approximately 12% of total trading on Asian stock exchanges in 2011, excluding Japan and Australia, (Kauffman, Hu, & Ma, 2015), in recent years HFT has been gaining prominence in Asian markets, where regions such as Japan and Hong Kong have been continuously upgrading their infrastructure and market structure to support HFT activities. For instance, in January 2010, the Tokyo Stock Exchange launched a new trading platform, the Arrowhead, to improve trading speed and security. Also, in Singapore, the Singapore Stock Exchange launched a new ultra-fast trading engine in 2013 to boost trading speed and connectivity. The abovementioned point is exemplified in Table 1 below, where it can be seen that HFT activities are indeed prevalent in these Asian markets.

Table 1. Proportion of HFT activities in the Asia Pacific region (Kauffman, Hu, & Ma, 2015)

Country	**Estimate**	**Information Source**
Japan	45% of equity trading	Bank of Japan
Australia	27% of equity trading	Australian Securities and Investments Commission
Hong Kong	20% of equity trading	Hong Kong Securities and Futures Commission
Singapore	~30% in derivatives, ~0% in equities	Singapore Stock Exchange

As such, with the development and increase of HFT activities in Asian markets, studies on HFT using only US and Europe market data is no longer sufficient to prove any hypotheses. Subsequently, a greater scope of study including Asian markets' data should therefore be used by researchers to provide better support for research hypotheses and relationships. This can aid in improving consistency of results in future HFT research.

5.2. Co-location and liquidity

Another area explored in our review of existing literature is the practice of co-location. Frino, Mollica, Webb (2013) concluded that co-location is beneficial for HFT as there is an overall improvement in the provision of liquidity in financial markets due to lowered latency, which Picardo (2016) defines as the time that elapses from when a signal is sent to its receipt. For HFT firms where voluminous transactions take place every second, it is essential for these firms to be able to minimize latency and exploit any speed advantages in order to gain a competitive advantage. This has resulted in HFT firms spending heavily on improving their computing technologies and proximity to the servers of stock exchanges through co-location. On the other hand, to support the lucrative demand for co-location from traders, stock exchanges have also been rapidly expanding and improving the infrastructure of their data centres. An example was provided in Merritt (2016), where the old New York Stock Exchange building was only 46,000 square feet while the new NYSE data centre in New Jersey features 60,000 square feet of co-location space.

However, the conclusion that co-location improves the provision of liquidity is subject to debate. While a main benefit of HFT has been the additional liquidity brought to financial markets, opponents of HFT argue that the additional liquidity is purely illusionary as the liquidity generated by HFT transactions lasts for extremely short periods of time, about a fraction of a second, before disappearing due to the high frequency of transactions and the ability of HFT traders to cancel their orders at the last minute before it is exercised. This is also known as 'Phantom liquidity' and there are several literature that address this issue, such as in Norges Bank Investment Management (2013). Therefore, while co-location does improve the speed that HFT can take place, if liquidity generated by HFT is taken to be 'Phantom liquidity'; any increase in liquidity from co-location will thus also fall under the same category.

Figure 3 below is a sample scenario with arbitrary values to explain the concept of 'Phantom liquidity':

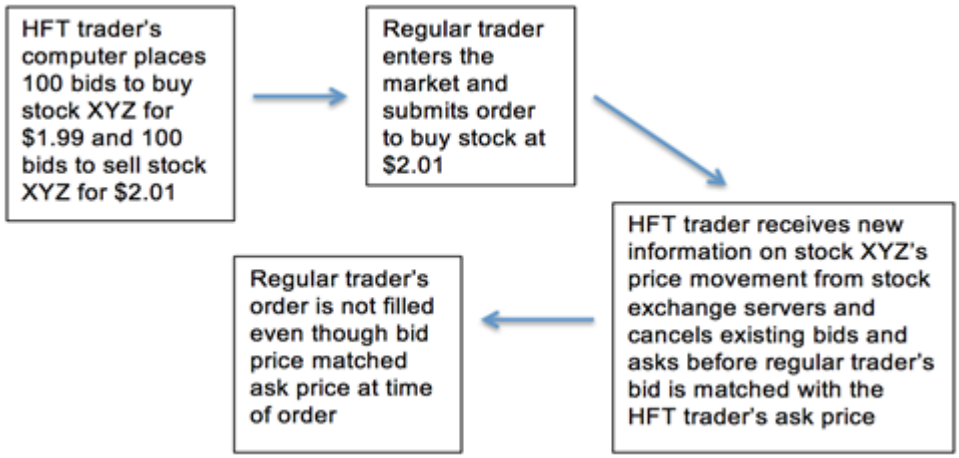


Figure 3. 'Phantom liquidity' explained

Therefore, to better prove the hypothesis that co-location does indeed improve the provision of liquidity, further research studies on 'Phantom liquidity' needs to be done in conjunction with existing research on co-location to determine the true effects of HFT on liquidity provision. While presently, there has been a few studies done to disprove 'Phantom liquidity', no definitive conclusion has been arrived at. If the concept of 'Phantom liquidity' can conclusively be disproved, it will provide greater support in concluding that co-location and HFT in general does indeed improve the provision of liquidity in financial markets.

5.3. Ethics in HFT

HFT has brought about several ethical issues, as discussed in subsection 4.2 and 4.3, to which Madonna (2013) has concluded HFT practices as being unethical. Two ethical frameworks, deontological ethics and consequentialism, were used in the existing literature to arrive at this conclusion. However, to provide greater support for any research hypotheses and conclusions, analysis should be done using more of the other ethical frameworks. We can propose another ethical framework – virtue ethics.

Virtue ethics is one of the three major approaches in ethics besides deontological ethics and consequentialism. It emphasizes virtues and moral character of a person. Rather than ethical duties and rules or the consequences of the particular action, virtue ethics focuses on the rightness or wrongness of individual actions (Stanford Encyclopedia of Philosophy, 2012). Therefore, to determine whether HFT is ethical or unethical, research studies should be done on firstly identifying and specifying actions in trading that are considered to be virtuous, and then secondly, evaluating whether HFT practices are “right” or “wrong” based on the virtues specified.

However, at the same time, we are aware that it is difficult to define, quantify or provide stronger proof using ethical frameworks, as ethics is a highly subjective area. This point is in fact a limitation of ethical research in HFT and as such existing studies on ethics in HFT face difficulty in providing evidence for the legitimacy of their conclusions.

To address the ethical issues surrounding HFT such as information asymmetry, transparency and fairness, stock exchanges and governments have introduced several forms of regulations to mitigate the ethical controversies, as per previously discussed in subsection 3.2 of this paper. This is so that as HFT is brought under regulation, any unethical practices can be better detected. As such, perhaps a better alternative in evaluating ethics in HFT would be to conduct research on the effectiveness of regulation in mitigating ethical issues. An example would be a study evaluating the correlation and effects of regulation on transparency or information asymmetry in financial markets. As an extension, regulators can also consider developing proper ethical guidelines to inform and guide traders away from unethical practices.

5.4. Summary of insights and recommendations

Overall, there remains much room for further research on HFT. Firstly, the scope of HFT research should be widened to include more regions such as Asian markets, where HFT activities are on the rise. This will improve the consistency of HFT research. Secondly, while it is indisputable that co-location brings about the minimization of latency, the question of whether it is truly beneficial to financial markets by providing liquidity is still an area of research that needs to be further explored in future HFT studies. Thirdly, HFT brings about many ethical issues that require the development of proper ethical framework and guidelines by regulatory bodies to be able to better evaluate any unethical practices in HFT. However, more research needs to be done in the future to determine what constitutes “proper ethical behaviour” in the highly subjective field of ethics.

6. Conclusion

With the proliferation of HFT in the trading markets, it is important for traders to gain a good understanding of HFT to reap the full benefits from this method. In essence, HFT rides on technological advancement to enhance trading by minimising latencies and achieving a high turnover of small positions. The rapid development of this strategy was fuelled by the technological advancement in stock markets, narrowing bid ask spread and regulatory change.

Traders need to be familiar with the common strategies of HFT, such as market making, arbitrage and liquidity detection, in order to quickly adapt their trading strategy based on the dynamic trading markets. As HFT is a relatively novel concept, there is still mixed market reactions as compared to the widely accepted traditional methods. Although HFT contributes to the market liquidity and pricing efficiency, it will also add volatility in trading markets that is detrimental to market stability. To mitigate the risks of HFT, regulators have been actively involved in managing HFT.

With the above understanding on the mechanisms and concepts of HFT, it is also important for traders to gain awareness on existing studies done on HFT and the possible directions of future research. Three key issues have been identified from existing HFT studies - the correlation between HFT and market quality, benefits of co-location in HFT on the provision of liquidity in trading markets and ethical controversies surrounding HFT practices. We have proceeded to provide further insights on the above issues that can guide the direction of HFT research in the future. Firstly, that is to increase the scope of data obtained in HFT studies. Secondly, further research is required to determine the true benefits of co-location on liquidity provision. Thirdly, the development of proper ethical guidelines and framework should be given emphasis by researchers and regulatory bodies of trading markets.

Taking into account of the above issues, traders will be able to gain a further in-depth understanding of key issues surrounding HFT. Overall, when equipped with a complete picture of the mechanisms of HFT coupled with an acute awareness of the HFT landscape in trading markets today, traders would then be able to make better decisions with regard to their optimal trading strategy in financial markets and critically evaluate the benefits of HFT to them.

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