

**Title:       Critically evaluating the effectiveness of high  
frequency algorithmic trading**

**Course:   Computer science**

**Module:   Professional practice**

**Tutor:     Francis Babayemi**

**Student ID: 4008609**

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## **Abstract**

Given the increased dependency on financial systems and the rise of computerised trading, this essay critically evaluates the effectiveness of high frequency algorithmic trading, which is a subset of algorithmic trading through academic research of journals, articles, and online sources.

## **Introduction**

High frequency trading is the process of trading financial assets such as equities and currencies on a very short time scale, typically just a few milliseconds or less, to gain short term profits. The increase in algorithmic trading activity has been increasing significantly. In the mid-1990s it was reported that algorithmic trading accounted for only 3% of the market, it is now reported that algos account for 85% of the US trading volume (Purba Mukerji et al. ,2019). For traditional traders, high frequency algorithmic trading causes a significant barrier due to the high frequency nature of these systems. Strategies commonly used within algorithmic trading systems include predictive data analysis, arbitrage trading, order analysis, news analysis and others. This essay also explores various associated costs (fixed and variable) due to different revenue streams. This allows for the profitability/returns to be evaluated and compared to other forms of investment and trading. Also, the impact on markets , public perception and economic morality are also assessed

## Different HFT systems

**High frequency trading (HFT)**, also referred to as "algo" trading, uses computer algorithms (a predefined set of rules/instructions to execute a given task) to trade financial assets (including currencies, stocks/equities etc) with the aim of making and maximising profits while minimising risks (also referred to as the "risk reward ratio"). High-Frequency Trading, as the term suggests, involves executing many trades in a short time frame. Each trade may last only a millisecond or even less. Thus, even a small profit in each trade can result in significant profits when measured in days and weeks. However, it is important to take in to account the bid ask spread, which represents the difference in valuations of an equity between the buyer and seller. This is commonly associated as commission

**Momentum trading** was first widely used in 1995 (McGroarty, F. et al. 2019) and involved purchasing equities when prices had recently been rising and entering a sell position, meaning profits are made as the price falls, when the price of equities started to indicate a decline, however the profitability of this strategy has been minimised due to more advanced forms of analysis, for example utilising the relative strength index (RSI). **Order analysis** involves analysing the flow of orders entering a stock exchange before they are executed and placing your own order with a slightly lower price that will be executed before the first order if filled. This can be achieved through the use of shorter and more efficient fibre optic cables, as well as higher computer processing speeds. **Simple arbitrage** involves the ability to simultaneously buy and sell the same asset within different exchange markets, for example buying an asset on the London stock exchange (LON) and selling it on the New York stock exchange (NYSE). The profitability of arbitrage is due to the discrepancies within markets caused by different trading volumes (quantity of shares or units of an asset being traded), as well as other market errors. This can also be implemented in forex (currency) markets by trading the discrepancy between currency valuations using triangular arbitrage (Ocean, 2018) which involves trading a currency to a foreign one, maybe multiple times, before converting it back to the original currency for a small profit. **News analysis** is more recent strategy involves algorithmically analysing live news audio and written articles to evaluate the change in market sentiment before retail traders evaluate the news outlet. This forms a very effective trading system, assuming it has instant access to news articles. These types of algorithms incorporate highly efficient code to analyse news before the public has a chance to access it.

## Profitability of HFT systems

Long term investors (not HFT) investment in funds which are designed to invest in growth and value companies e.g. in the US. This allows investors to get a potential return on their savings without the need to regularly trade assets. This has the benefit of simplicity and compounding returns, however it can be argued that to mitigate capital risk, profit taking must occur. Also, high frequency trading may not always benefit from compounding, the profits generated can be re invested by the algorithm, due to this many firms have been seen to significantly outperform the SPX 500, especially during volatile periods. When considering the “profitability” of any computerized trading system, the time taken to setup such a system is also important. The markets (and market characteristics) are continuously changing and the time taken to implement a particular trading system is highly critical. If the “setup” time is unreasonably long, then the market characteristics may change. Other factors including commissions, Buy-sell spreads etc will also change with time.

## Costs of HFT systems

**Hardware costs** of setting up a HFAT system depend on how the system is intended to be used. A basic HFT system can be set up at home with a dual core processor and 2GB of ram, this can cost from £100 - £300. However, most firms utilise multi-threading code which require higher cores and possibly multiple CPUs. This also requires an increase in RAM. A 32 core CPU can cost from \$3000 to \$6000, highly profitable firms will further invest in to multi core threading and efficient connection which allows nanoseconds to be shaved off. **Software costs** of such systems is dependent on whether the user wishes to use a commercially available high frequency system to implement their bespoke algorithm within or whether they decide to program their own software. Producing an implementation specific software to trade within may behave the user in terms of efficiency and on-going costs. However, the cost of such system can vary, depending in the type and complexity of code to be used, i.e., multi-threading cores, the start-up cost will be significant however, due to decreased commission and other fees, the user may incur lower costs long term. **Network costs** of running such systems can be significantly high, this is due to the advantage of utilising a high-speed fibre connection which allow not only orders to be filled earlier, but also provide more accurate pricing of equities. This is further supported by (Baron, M. et al. 2019) who investigated the impact of latency in HFTs and concluded that “relative latency is important for success in trading on short-lived information, for risk management in liquidity provision, and for cross-market arbitrage.”. This can significantly increase profit margins due to the increased volume of orders processed and also executing the trade at the best prices.

## **Implications of HFT implementation**

### **The advantages of high frequency algorithmic trading:**

Firstly, and most importantly, the human decision element is eliminated, this task is replaced by the objective decision making of the software algorithm. This can be significantly beneficial when; mitigating or hedging risk within markets since subjective emotions will be eliminated, however, due to this nature it can also cause significant risk (see below). This can also be beneficial when taking on additional risk, especially during a general dip in the market. Another advantage is that decisions on a trade (conditions for taking on a trade) and be evaluated very quickly due to the hardware and software efficiency. This allows the system to make decisions at such a high frequency that a human would not be able to replicate. A further advantage of such system is its ability to analyse previous trades (to check for mistakes) at a high frequency. This is beneficial when conducting predictive analysis, as well as taking advantage of price arbitrage (disparities within markets). Also, due to the nature of the computerised system to run 24 hours a day, the productivity is significantly higher when compared to manual trading.

### **The Disadvantages of high frequency algorithmic trading:**

The elimination of the human element can also be a disadvantage. For example, identifying bugs/errors within the software or simply identifying new factors, e.g. political news, which may lead to extended losses not anticipated when writing computer software. Historically events have occurred where algos were deemed responsible for causing flash crashes within the market (where price drops significantly for a short period). Another disadvantage to implementing such system is that it incurs significantly high start-up and day to day running costs. However, it can also be argued that the running cost for such systems (per hour) are much lower than salaries typically paid to Traders/employees.

# Impacts of HFT implementation

## Changes in bid ask spread over time

The bid ask spread is the difference in price that the buyer is willing to pay and the seller is willing to sell at. This can be interpreted as one form commission since the buyer will have to pay a higher price to satisfy the seller.

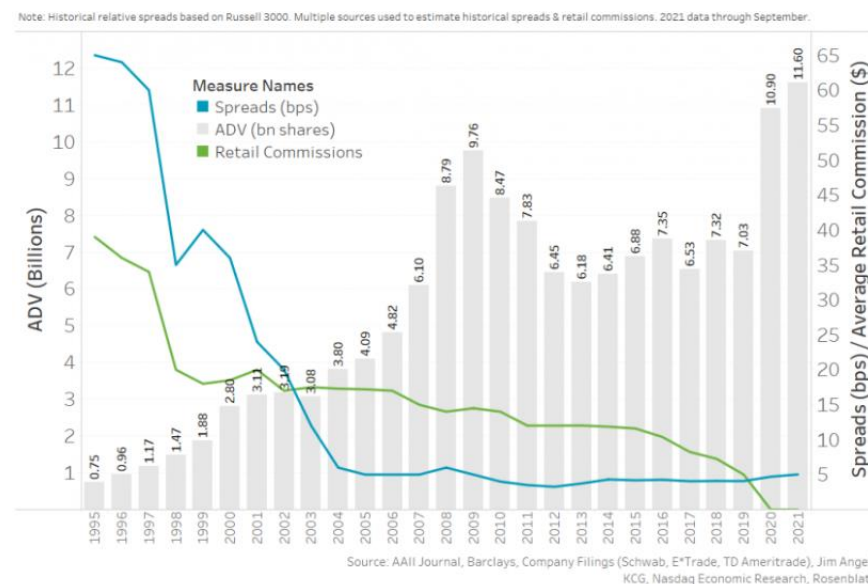


Figure 1: Changes in spread over time (Russell 3000), (Nasdaq.com, 2021)

The spread of the Russell 3000 index shown in figure 1 had a dramatic decrease from periods 1995 to 2004 (Nasdaq.com, 2021), this has been determined to be due to the increase in electronic and algorithmic trading. It is argued, that because algorithms are conducting trades at a drastically higher frequency than humans, the spread has decreased to the availability of algorithmic buyers. An experiment conducted by (Purba Mukerji et al., 2019), found that “*liquidity rose sharply as AT was introduced with most of the liquidity rise realized at just 10% AT participation.*” However, a counter argument can be put forward that systems are not obliged to purchase assets, but make a decision to do so, meaning it is possible the decrease in spreads is solely due to access to markets through advancements technology i.e. smartphones rather than algorithms themselves. Further evidence to support this theory, is the fact that the decrease in spreads has stagnated meanwhile computer and internet speeds continue to increase.

## How HFTs can manipulate markets

Order analysis can be manipulated to falsely anticipate market sentiment. This is done by spoofing (Fletcher, G.-G. S., 2021), where orders, usually sell, are sent to the exchange but retracted before they are filled. This causes algorithms to anticipate large orders when in reality they will not go through, causing algorithms to sell or buy positions. This type of manipulation caused a flash crash in 2010 where an estimated 1 trillion dollars was wiped from high cap US companies within five minutes.

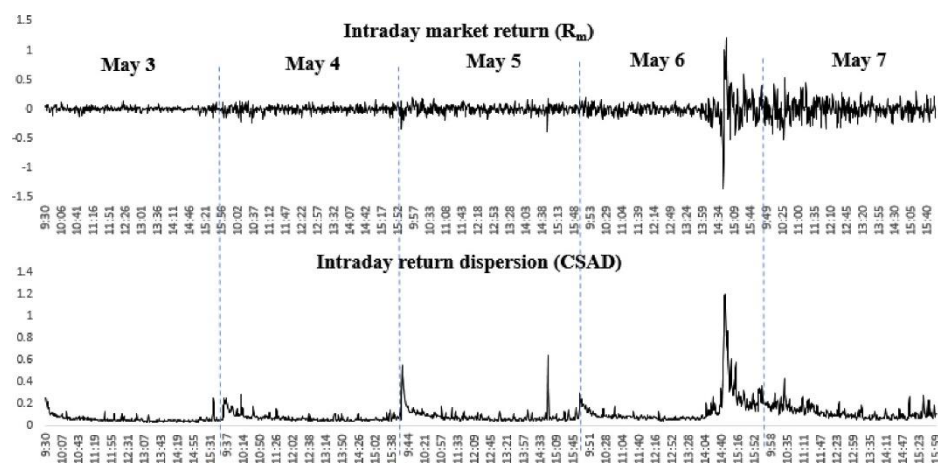


Figure 2: \$4B sell orders during flash crash around 2:30pm (Demirer et al. 2019)

The market return and return dispersion diagram shown in figure 2 allows (Demirer et al. 2019) to observe a “*drastic increase in volatility for E-mini S&P 500 contracts around 2:30 PM*”. This was due to fake sell orders sent by a day trader which were retracted but caused algorithms to anticipate market sentiment resulting in a rapid decrease in price

## **Conclusion**

The effectiveness of algorithmic trading within financial markets in terms of profit can be significant, depending on the efficiency of hardware, software, and algorithms. This can be clearly observed when comparing the returns historically obtained from HFT firms compared to those obtained from traditional trading firms. This is mainly due to the absence of human emotions and subjective computer algorithms. However, this requires high initial capital to start up which may cause a significant barrier to entry. It has been determined that 80% of trading volume in the US is algorithmic, which causes tight competition to shave off milliseconds through efficient programming and hardware architecture. It is commonly said that algorithmic trading is responsible for lowering commission for retail traders, however it could also be argued that algorithms can be turned off and are not obliged to always purchase assets. The significant increase in the presence of high frequency algorithmic computer systems has been known to manipulate markets due to its ability to rapidly send

and cancel orders which causes a significant decrease in price by manipulating already implemented algorithms through spoof orders. This type of event resulted in a significant flash crash in 2010. Due to this, many firms ensure their strategies are not disclosed allowing them to have an advantage within their firms.

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# **PART 2 self reflection**

## **Introduction**

In this section of the assignment I have reflected on the previous assignment of this module, which was a group exercise to design, develop and present a digital solution for an anonymous feedback application. I have tried, below, to give my personal account of the similarities and differences between the two assignments and also a true account of the challenges I faced as well as the things I learnt/achieved, which I can take with me as I move through the degree course in to next year.

## **Description**

The first assignment was much more practical. We were required to design and develop a digital solution as a group and then do a group presentation. The presentation included our thoughts and arguments behind the design decisions and how the project was developed to a final viable solution

This second assignment required me to research a subject, in this case high frequency trading, by myself. Then, to decide which points/topics were important enough to incorporate in to my written report as apposed to a presentation (as in the previous assignment). For this second assignment I was also required to draw conclusions on various aspects of high frequency trading without the help of others in a group

The first assignment required me to not only collaborate but also ensure all members of the group had confidence in their ability to complete the task assigned to them. The groupwork demanded all members to communicate with transparency, meet strict deadlines, and to work to the best of their abilities.

## **Feelings**

During the first assignment (group project), I felt that it was vital that the group started to breakdown the assignment/project in to smaller subtasks as quick as possible. This is because I felt that early discussion of various tasks would allow for any concerns to be addressed early. I also felt it was a good idea to assign tasks based on individual strength and weaknesses. Looking back, it would have been beneficial if we had everyone keeping an eye on other people's tasks and provide guidance and contribution when required. This would have provided a more diverse outlook on all tasks, as well as allow for more efficient peer reviewing. However conducting research solely by myself was beneficial for me in improving my academic understanding of publications, effective citation and wording.

## **Evaluation**

I believe the group project was beneficial to me in further improving my ability to work efficiently within a team. The leadership and task distribution within the group was clear allowing all members to work effectively. I feel that project management was vital in scheduling and ensuring all members were up to date. However, the group would have benefited from a democratic biased leadership, this would allow members to further express their view points on the tasks, I believe this caused some backlog of contribution

## Analysis

I appreciated the opportunity to do both assignments. The first assignment was more challenging because I was working within a group. This is something I rarely get a chance to do and it turned out to be very rewarding. I didn't know what to expect when I started the first assignment. Most of the group members were new to me. By the time I completed the assignment, I was good friends with all the group members. I appreciated all their hard work. I hope they appreciated mine.

The presentation was a different challenge. I had to communicate with all the other members of the group. We had to decide on the contents of the presentation, we also checked each other's slides. I think the presentation went very well.

The requirement of the second assignment was more familiar to me. Involving research and report writing. This is something I have done quite a few times previously and therefore I was able to start the task/assignment without much difficulty. Once I started the research, I was surprised by variety and number of trading methods and strategies. I found the research, I was doing, very interesting. It was also computer related which increased my interest further. Surprisingly, the task of obtaining (researching) actual returns/profits for high frequency algorithmic trading (HFT) was very difficult due to the secrecy of the various trading algorithms. But I did manage to find lots of figures and data to support my arguments for returns on funds for HFTs.

## Conclusion

I feel I have benefited significantly from both assignments. I'm glad that both assignments were so different. The first assignment required the design, development and presentation of an application as a group, while the second was the sole exercise in researching a subject and writing a report with my own personal conclusion.

If I could do the first assignment again, I would (as a member of the group) break down the project into better sub tasks and then try and assign how long it would take to do each sub task. Possibly, I would also ask the group to do a gantt chart. Also, as always, as a group we were short of time at the end prior to presentation. Developing a gantt chart at the beginning would have helped us to leave more time at the end for the presentation.

If I could do the second assignment again, I would again break the tasks down in to better sub tasks and assign how much time I would require for each. I would also leave more time to research the returns/profits from HFTs which was very hard to find out in the end.

## Action plan

When I do a group assignment again, I will know what to expect, I will definitely break my tasks down in to smaller sub tasks. I will ask all the group members to review the work of other group members, and also add their contribution. For the presentation I think we would really benefit from a mock presentation which we didn't have time to conduct this time. For the second assignment I would allow myself more time to look at the various trading algorithm systems.