High-Frequency Trading
Reading Project

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Practical Example: Flash crash - Dino Feratovic
Conclusion and Own Opinions - Everyone
Further Reading - Everyone

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1. Introduction

As the world is developing, with new technologies being produced, society is moving towards a more automated way of living. Nowadays you do not need to visit a bank office to trade on the financial markets. The only requirements are money, a computer and internet connection. Today, the computers are much faster than a human mind which has made investors develop algorithms to trade for them much faster than they can trade themselves. This is called high-frequency trading (HFT) and will be the main subject for this report. As of today, about 50% of the transactions on the U.S. stock market includes an HFT-trader (Nasdaq, 2022). The report will include an in-depth explanation of the term HFT and also discuss some of the economic risks of trading with these intellegent algorithms. At the end of the report there is a discussion and some opinions written by the authors of this project as well as a reading-guide for further reading on this topic.

2. Theory

In this section the term high-frequency trading will be presented, as well as its risks. A practical example containing a mistake that led to a Flash Crash will be described. Regulations within

2.1. What is High-Frequency Trading?

As technology develops, actors across the society, in different markets, have to adapt to the new circumstances. The technical evolution has affected trading on the stock exchanges worldwide. High-frequency trading allows large transactions in fractions of a second. In order to add liquidity to the market, exchanges started to offer compensation to companies for doing so, about 15 years ago (Chen, 2021). In this phase high-frequency trading became interesting for organizations since almost every exchange hired providers to add liquidity and competition for existing quotes on the market. For example, the New York Stock Exchange has a group of providers called Supplemental Liquidity Providers, which was put to work after the fall of Lehman Brothers during the 2008 Great Recession. In this case New York Stock Exchange pays a fee to the liquidity providing companies (Chen, 2021).

By using advanced computer algorithms a trader is able to execute a large number of transactions in the blink of an eye. These algorithms are able to scan and analyze markets and execute orders based on the condition of the specific market (Chen, 2021).

The softwares aim to buy the assets at the lowest price possible and then sell them at a higher price during the day, but often immediately. The algorithms can be formulated in different ways depending on what the specific trader wants to achieve. Here are four examples:

1. The algorithm identifies an upgoing trend of the price of an asset and secures it with hopes of an ongoing trend.

2. The algorithm identifies an upgoing trend of the price of an asset and sells it with anticipation that the highest price is reached.
3. The algorithm exploits the lag time between historically correlated assets, in terms of price patterns. A scenario that traders often refer to is the positive correlation between crude oil and oil firms. If either the crude oil or the oil company increases in price, the other one is likely to increase as well (Wullweber, 2020).
4. The algorithm scans business reports, articles from financially oriented newspapers, tweets and much more. The program is looking for keywords such as "*Growth", "Profit", "Loss"* or "*Fraud"* and makes decisions based on the frequency of the terms. These algorithms contain other parameters as well, including information about the company's revenue and earnings, with numerical values (Economics Explained, 2019).

As written before there are many other ways of performing algorithmic trading besides the ones presented above. In general, high-frequency trading requires a lot of data, regardless of the choice of method. In order to be efficient and maximize the value of the algorithms a trader needs fast computers. Actually, it is almost impossible to be competitive without the best computers on the market. In the current situation, the competition between the biggest HFT-firms have reached a level where nanoseconds can be crucial. There is no longer an option to trade assets on the New York Stock Exchange, NYSE, from other places than the hub if the firm's business is centered around algorithmic trading. In other words, the closer to the financial trading center the computer algorithm's orders are initiated, the better are the chances of a successful transaction (Wullweber, 2020).

New advanced technologies, such as machine learning and AI, have revolutionized algorithmic trading. Before, high-frequency trading was totally speculative and luck was always a factor taken into consideration. The most successful companies were the ones with the most optimized code and they gained a huge advantage in terms of speed because of that. These parameters are still vital, but machine learning and AI add a new dimension to the trading method. Nowadays, when the algorithms are able to scan annual reports, newspapers and social media platforms, the firms can not only make decisions based on course trends but also based on fundamental information. This is another way to gain an advantage over other investors. The algorithms are able to process the information in less than a second, compared to a traditional investor who may need about 5 to 10 minutes to look through an annual report before making a decision. The algorithms ignore emotions and thus make rational decisions in all situations (Economics Explained, 2019).

2.2. Major Risks

High-frequency trading is also associated with several risks, which will be discussed in this section.

2.2.1. Amplification of Systematic Risk

High-Frequency trading amplifies the systematic risk (which is often considered to be the greatest risk with HFT) in several ways. Firstly, it intensifies market volatility. Because algorithms are programmed to react instantaneously to market change, they will, during high market activity, greatly widen their bid-ask spread, which will increase the volatility.

Secondly, due to the high integration between markets and asset classes in the global economy, a meltdown in one market can easily spread to other markets, and similar for asset classes. An example of this ripple effect is the global recession that followed from the US housing market crash, although it was not a result of HFT.

Lastly, HFT increases the uncertainty among investors. Volatility can be seen as a measure of the market uncertainty and, as mentioned earlier, increased volatility can be a result of high volumes of HFT. During a market collapse the uncertainty of the future increases and investors (including trading firms) often choose to scale down their market positions to minimize the risk of capital loss. This will eventually put even more downward pressure on the market. Furthermore, as the market decreases, stop-losses will be activated and a negative feedback loop can be created. This will in fact increase the market-uncertainty while decreasing the investors confidence over the long term (Picardo, 2022).

2.2.2. Errant Algorithms

An additional risk associated with HFT is the one concerning errant algorithms. The most common example up to date is the fall of Knight Capital. In August 2012 Knight Capital created a software to be able to use the new electronic trading platform launched on the New York Stock Exchange. However, there were some major faults with the algorithm, causing it to buy high and sell low. For every trade made they were losing between 10 and 15 U.S. Dollars, and after just one minute around $10 million were lost. This resulted in a cumulative loss of $440 million during a time period of 45 minutes and, eventually, pushing them close to bankruptcy and later acquisition by Getco LLC (Harford, 2012).

2.2.3. Loss of Confidence in Market Integrity

People invest in financial markets because they have faith in their integrity. However, as markets act irrational and are incused by high volatility, more conservative investors can lose faith and confidence in the prevailing climate, and will therefore drift to a market abandonment. Examples of issues are when Nasdaq stopped trading for three hours because of a software problem back in August 2013, or in April 2014 when a computer malfunction at IntercontinentalExchange Group's two U.S. options exchanges caused around 20,000 incorrect trades which consequently had to be canceled. But the most relevant example of loss of confidence in market integrity due to HFT is the Flash Crash back in 2010, which is described further later in the report (Picardo, 2022).

2.2.4. Ghost Liquidity

The difference in time horizon between HFT and normal investing is large, as traders rarely hold their positions overnight while classic investors are looking at a more long-term scale. A result of traders only holding their assets for a short period of time is that it creates "ghost liquidity". Opponents to HFT point out that the liquidity created is not real and before a regular investor can buy the asset, it may have been traded several times among high-frequency traders. Therefore, as the standard investor or human trader places the order, the big liquidity created by HFT may have disappeared (Corporate Finance Institute, 2022).

2.2.5. Algo-sniffing and spoofing

A trading technique that is being used nowadays is called algo-sniffing. The basic concept of this technique is to place small orders to find other softwares that are trading that particular stock (Ablan, J. 2007). If it detects another high-frequency trader, it will try to pick up trading opportunities, either with or against the high-frequency trader. A category within algo-sniffing is called spoofing. The basic concept of spoofing is to place orders and then quickly cancel them to create fake-demand for a certain type of asset. Normally, supply and demand is determining the price of an asset which means that the spoofers can control in what direction they want the market to move. This method is illegal in the US because of its market-manipulation power (Becker, S. 2021).

2.3. Practical Example: Flash Crash

On May 6, 2010, an unusual event occurred. The US market lost approximately one trillion dollars in just 36 minutes. This drop eventually recovered and was back to its normal level the same day. The event is known as the flash crash of 2010. The fascinating part of this extraordinary event is that it was caused by one man, Navinder Sarao (Verity, A. Lawrie, E. 2020).

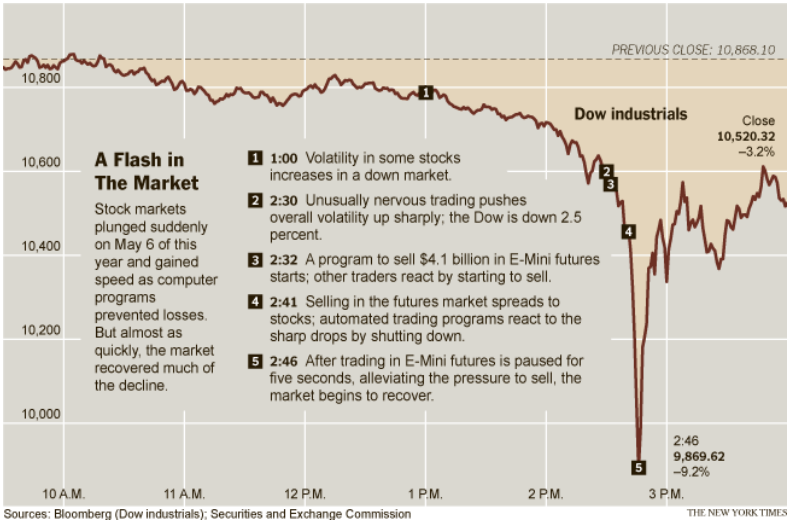

Figure 1: The price chart of the Dow Jones Industrial Average index on May 6th, 2010 (Batman,2012).

Usually, the trades that occur in the market are caused by high-frequency traders that can spot a movement in the market before the orders even are executed. Sarao was aware that many

high-frequency traders used the same software as him and were triggered by the same signals. He used this information to create his own algorithm, where he made orders and let the high-frequency traders place orders before canceling his own orders and therefore controlled the market movement (Bloomberg Quicktake: Originals, 2020). Therefore he made profit on the loss of the high-frequency traders. This method is called “spoofing” and is illegal in the US. Sarao was living at home in the UK and placed these big orders in his bedroom. During his active time of trading during the day, he did not cause the market to crash. The crash occurred when he turned off his software or computer. Some sources state that his mom said it was time for dinner and when he turned off the program, the market crashed. He triggered a big sell order from Waddell & Reed Financial Inc. where they sold $4.1 billion in E-mini S&P 500 futures contracts (Half as Interesting, 2021). The HFTs picked up these contracts and started to sell them to each other making a vicious circle that forced the future markets down in price. When the arbitrageurs saw an opportunity to sell their stocks and pick up future contracts instead for a cheaper price it led to the crash of the stock market which is today known as the flash crash. This story ended sadly for Sarao though because he was convicted in the US for spoofing. He did not go to prison because of his cooperation with the government and because of his medical condition but was given a fine of around ten million pounds (Verity, A. Lawrie, E. 2020).

2.4. Regulations

In order to avoid similar scenarios as the Flash Crash described above, discussions about the implementation of regulations against HFT are more frequently being held. It is clear that HFT has several advantages compared to standard trading, one is that it is able to perform at a much faster rate. Two suggestions to limit the speed advantage are through “*digital speed bumps*” and introducing a “*minimum resting time*”. A digital speed bump is a tool for increasing the time between an order being placed and when the asset is secured. However, the speed bump only works in one direction. Consequently the time it takes for information to reach the trader is not affected. The minimum resting time on the other hand, limits how quickly traders can change the orders placed. Instead of delaying the time it takes between a placement of an order and the time of securing it, this regulation would make sure that the order always spends a minimum time in the order book.

An additional measure to regulate HFT would be to increase the tick size, which is the minimum price movement of a trading instrument. This means it becomes more difficult for traders to make small improvements on the best quotes, i.e placing an order that is just a little cheaper than the cheapest order on the market for the given asset, and vice versa. Lastly, it has been suggested that traders must have a minimum order ratio, i.e it limits the maximum orders a trader can submit relative to the number of trades. Traders often change or cancel the orders as the market fluctuates, resulting in that there seems to be more live orders than eventually will be executed. This regulation would make the market more transparent and hopefully remove ghost liquidity (Ladley, 2019).

3. Conclusion and Own Opinions

As seen in section 2.1 HFT contributes to adding liquidity to the market, no matter which type of algorithm that is used. HFT has evolved over the years; going from pure technical analysis, to being able to analyze the correlation between for instance companies and corresponding asset classes, and today drifting towards a more fundamental view as algorithms are getting better at analyzing texts, such as annual reports.

Although HFT is getting better and more advanced, it still has some flaws. Examples of these are amplification of systematic risks, errant algorithms and ghost liquidity. Even though these are known, they seem hard to eliminate and some risks (these ones or new ones) will probably always be present. During the flash crash in 2010, the bait from Sarao initiated signals that the algorithms of the high-frequency traders picked up which made the market crash. The method he used is called spoofing and is illegal to perform and in the future more regulations can possibly be formulated in order to reduce the systematic risk. However, as the flash crash occurred spoofing was still illegal, which may imply that regulations do not have the desired effect. Therefore further measures may be needed to reduce the risks.

As the global economy is getting even more integrated the systematic risk from ripple effects increases as well, which makes it difficult to eliminate. Something that would be easier to regulate is the launch of new trading algorithms by big trading firms. To minimize the risks of events like the fall of Knight Capital, algorithms could be examined by a third party actor before launch, or even be runned in a simulation, to make sure there are no errors. Furthermore, another idea is to implement different kinds of certificates provided by the exchanges for the big HFT firms where the certification, which allows them to trade, also includes responsibility and some restrictions they have to follow.

4. Further Reading

In this section, there are different links to articles and video clips containing this subject for the readers that are interested to learn more about this topic.

If the reader wants to learn more about the flash crash, the video "*The Wild $50M Ride of the Flash Crash Trader"* made by Bloomberg Quicktake: Originals provides relevant information:
https://www.youtube.com/watch?v=_ZDEWVJan0s

If the reader is interested in the transformation of financial markets and which role HFT plays in it, the ECB-report "*High Frequency Trading and Price Discovery*" by Broogard (2013) provides relevant information:
https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1602.pdf

The paper "*The impact of high-frequency trading on the Swedish stock market - based on liquidity and volatility*" by Björkman and Durling (2018), gives a deeper understanding of the impact of HFT on the Swedish stock market, with respect to liquidity and volatility measures. Thus the report does not cover this topic, this paper is recommended to the interested reader.
https://www.diva-portal.org/smash/get/diva2:1222183/FULLTEXT01.pdf

If the reader is interested in how regulations regarding HFT can be formulated in the future, the writers suggest chapter 5 in "*The Design and Regulation of High Frequency Traders"*, written by Ladley (2019). The author presents 6 ways of regulating high-frequency trading, including fees, speed bumps and a tax system. Ladley does also discuss possible outcomes if the regulations were to be applied in the future.
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