High Frequency Trading

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December 1, 2012

Contribution declaration
This report has been written and edited jointly by both authors.

During the last two decades the financial market has undergone significant changes mostly due to the development in informational technology. These developments have sparked new ideas and opportunities to make money on the market. Computer-aided trading has been around since the late 90's but it wasn't until 2006-2007 that the financial market saw a boom in the trading volume for algorithmic trading. Mostly due to the NMS[1]-regulation in the U.S. and MiFID[2] in Europe which were put in effect 2005 and 2007 respectively to make the financial market more uniform, fair and forced brokers to make trades at the best prices no matter on what exchange the trade took place. [1]

1 History and development of High Frequency Trading

High Frequency Trading, commonly known as HFT, is one of the more recent way of trading on a financial market that has gotten a lot of public attention. There are some common misconceptions on what HFT actually is and how it is affecting the financial market. In this paper we will try to explain HFT and some of the common strategies HFT-firms employ. We will also analyze and discuss the effects HFT has had on the market and the accompanying risks.

1.1 Algorithmic trading

HFT is often labeled as a subset to the notion of Algorithmic trading, AT. AT in turn is a way of acting on a trade market by means of computer-aided algorithms. By programming algorithms to analyze the market and/or a single asset such as an stock, the algorithms give indicators that can be used to quickly find a good trading strategy. Often these algorithms are based on strategies that has been used before the "IT-era". Examples of such strategies could be to find arbitrage[3] opportunities or to find the best way of making a large investment for a long-term strategy.
One clear advantage of using algorithms to do these analyzes is that they are faster than a human. A trader that can quickly assess macroeconomic news will oftentimes have an advantage over slower traders.

1.2 High frequency trading

To distinguish HFT from AT we will try to look at some of the characteristics of HFT that are used[2]. For example; a HFT-strategy often involves a large number of orders, orders that are placed can be rapidly canceled, positions are held for a short while and they require as low latency as possible(i.e. they need access directly to the market and should have the fastest connection)[4]. The time-aspect of HFT is very important and on today's market the time is measured in microseconds. Studies have shown that on average a stock is held for 22 seconds in the U.S.[1]
An even more interesting fact is that around 73% of the trading volume on the U.S. equity market is due to HFT but only 2% of 20 000 firms trade using HFT[3].

[1]National Market System regulation, a collection of regulations that strengthens the financial market. `www.sec.gov/rules/final/34-51808.pdf`

[2]Markets in Financial Instruments Directive `http://ec.europa.eu/internal_market/securities/isd/mifid_en.htm`

[3]Profit on price-differences on different markets.

[4]For a full list of characteristics, look at [2]

1.3 Common HFT strategies

The strategies involved in HFT are often fairly simple though the exact implementations of the strategies are company secrets. The market for HFT is constantly changing and so are the algorithms. We will try to deduct some common overlying strategies used in HFT, for a more complete deduction read[2].
A relatively easy strategy to understand is Statistical Arbitrage. This strategy finds imbalances in prices on for example an asset on different markets and profits on the difference. But it can also involve correlated assets such as a derivative and it's underlying asset, if the asset rises this will have an impact on the price of the derivative. The strategy then is to profit on the difference before the price of the derivative has settled.
Another interesting strategy is called Filter Trading. This is a sort of news-analyzing strategy where the algorithms searches for new announcements or rumors etc that will have an impact on assets and quickly assess these news and forms a strategy to profit on the movement that the stock will have when the general public will be aware of the news. It can also involve searching for certain behavior of stocks such as large trading volumes and acting on that.
The last example is a strategy called Rebate Trading. It is based on taking advantage of rebates given to traders that add liquidity to the market[5]. On exchanges these rebates could be a fraction of a cent(dollar) per shares that is payed by the exchange. And conversely if a trader takes liquidity from the market they have to pay a fee that is higher than the rebate for adding liquidity to the market. In simple terms the algorithm buys and sells an asset at the same price but acts as a liquidity-provider in both cases by some strategy and hence earn no profit but the rebates. Rebate trading is an old strategy that traders have used for several years but has recently become much harder to utilize. With HFT new ways of earning rebates has become more apparent just because of the speed that the algorithms work at. And if the algorithms does these types of trades often and in larger volumes the profits suddenly becomes interesting.

1.4 Market-manipulative strategies

While the above legal strategies are used by many HFT-firms there are still firms that conduct high frequency trading with strategies that are illegal. Oftentimes these HFT-algorithms are the ones that get the most spotlight in the media and perhaps these rogue-algorithms have cast an unfair cloud of distrust over HFT. Most of these strategies are considered to be market-manipulative and in September 2010 the company Trillium Brokerage Services was fined $1 million by FINRA[6] for quote: "...using an illicit high frequency trading strategy and related supervisory failures"[4]. One of the strategies that Trillium had been using was "Layering". It is based on using the speed of HFT to post bids and then immediately cancel them. To understand this you can think of a stock that has a certain bid and offer at the moment, for simplicity set the bid at $10 and the offer at $10.05. Now the HFT firm currently owns a portfolio containing a certain amount of these stocks and wants to sell them but are not satisfied with the $10 bid. So they post an offer to sell the stocks at $10.03 in a Dark pool[7]. Now since the bid is only at $10 the HFT firm have to either be lucky and get a hit on that if the market for the stock improves or they can try to manipulate the market. This is done by posting a lot of bids slightly lower

[5] An order adds liquidity to the market if it has a limit that can't be met instantaneously and thus is put "on hold" until the market price has reached the limit.

[6] Financial Industry Regulatory Authority

[7] A trading venue that is hidden from the public exchanges. Perfectly legal way of trading and accounts for around 12-13% of the trading in the US today[5]

than the $10 bid. These bids are done publicly and in large quantities, though immediately after the post the HFT firm cancels those bids. This will create the illusion that someone is about to make a big investment in the stock and the buying pressure gets higher. There are algorithms that conducts these sniff-outs and find such events and in this case those algorithms start putting up their own bids to front-run and hopefully make a profit later on. The bids will be $10.01, $10.02 and so on, suddenly one of these algorithms hit the $10.03 bid that the HFT firm had posted and the HFT firm make a profit. This routine will take place during fractions of a second so a regular day trader will never know what hit them, they are therefore rarely involved in these matters. But it doesn't end there, since the HFT firm posted a bid that didn't get met immediately they're also entitled to the rebate that is given to traders that add liquidity to the market as explained above. In the end, the HFT firm made a substantial profit but as you might have understood by now this is considered to be market-manipulation which is illegal. The above example was inspired by Felix Salmon's example in [6].
Another strategy that is used is "Quote stuffing". It also relies on the fact that HFT-algorithms can post a lot of offers and cancel them immediately. But in quote stuffing this is used to "flood the system", i.e. slow down the market to other traders and therefore achieve an advantage over them. This strategy is also considered market-manipulative and illegal.

2 Impacts on the market

The most hazardous event on the stock market in which HFT's have been involved occurred on May 6, 2010. In the course of 30 minutes the Dow Jones Industrial Average dropped about 9% followed by an equally quick rebound.
This event is now known as the Flash Crash and is usually what HFT critics use as an example of the great risk and volatility HFT's create for the market. In the paper "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market" by Kirilenko, Kyle, Samadi and Tuzun[7], the authors conclude that while the Flash Crash was not started by HFT traders, their trading strategies during the crash greatly enhanced the volatility. As an example the authors claim that HFT traders lowered the price of E-mini[8] by 1.7% during the time-frame 2.45.13 pm and 2.45.27 pm. The authors further claim that non-HFT investors entered the market and initiated the price rebound.
In defense of HFT traders with respect to the events of the flash crash other articles, such as High Frequency Trading by Gomber, Arndt and Uhle, conclude that if the market had had circuit breakers[9] in effect such as the ones in Europe the crash would not have been nearly as severe. As a precaution to prevent that these kinds of events happen again circuit breakers have been put in place throughout the market.
On another note, even though HFT's might have been the reason for the abnormally fast price-drop, they might also have been the reason for the fast rebound. Quoted from Jim Simons[10], "In my opinion, the system worked beautifully compared to the way it worked in ... 1987", when comparing the flash crash to the crash of '87 where the market dropped 22% without rebounding[8].

When looking at the current academic research and empirical studies on how HFT affects the market the general conclusion is that HFT is beneficial for the market, by quicker price

[8]Stock market index of futures contracts traded on Chicago Mercantile Exchange.
[9]A circuit breaker enforces a trade stop in stocks if their prices vary too quickly.
[10]Hedge fund manager of Renaissance Technologies

discovery[9], lowering the amount of arbitrage opportunities[10] and decreasing the short term volatility[11] or that HFT has no apparent effect on market volatility. But there also exists contradictory papers that conclude that HFT hinders price discovery and increases market volatility[12]. The existing literature on the subject is scarce and provides no direct evidence for either claim. Considering market volatility the most common claim is that HFT traders do not increase volatility, but that there is no useful data on HFT's effect during a financial crisis. In one paper concerning the effect of algorithmic traders on the foreign exchange market the authors state, "Furthermore we find no evidence of the often-voiced concern that algorithmic trading leads to excessive volatility in any of the three currency pairs we analyze. One caveat we would like to add to this analysis is that our study does not cover a truly tumultuous period in financial markets; we are thus still uncertain about how algorithmic traders may behave in a crisis period."[10]
That being said, the current general opinion of the academic world seems to be slightly positive towards HFT, whereas the general opinion about HFT from other market actors is that it is an unfair development that leads to market instability. As an example, pension funds are intercepted by HFT behavioral algorithms and their revenues are not as high as expected[13]. It seems to be quite obvious that computer-aided investments have many advantages over regular investors which in turn could disincline regular investors to invest in the market. A reason for why HFT firms might be vilified as the cause of the recent years of high volatility is as the founder of the HFT-firm Tradeworx described to CNN, "Look, it's the oldest trick on wall street to look for a scapegoat when you can't explain your own performance"[11].
It is generally hard to know for certain how the HFT firms affect the market since researchers do not have access to how the algorithms actually work and are not likely to get any information from the firms using HFT. This also adds to the general distrust of these new techniques as regulators, other investors and the public don't know how it works and what the risks might be.

3 Discussion

3.1 The hunter becomes the hunted

It might seem that these algorithms are impossible to beat and that the original daytrader is ever at the disadvantage. This is usually the case, but in 2008 two Norwegian day traders managed to beat a trading-algorithm set up by Timber Hill, a US based company operating on the Norwegian stock market[12]. Mr Larsen, from Stavanger in Norway, noticed that as he purchased stocks in the shipping company Odfjell the automatized algorithm from Timber Hill sold the same stock for a slightly higher price. By continuously buying small volumes of stocks Mr Larsen was able to raise the value of the stock to a level above the initial value. He then sold his stocks in larger chunks, making 37 700 Swedish crowns in two hours and 45 minutes. This resulted in a trading-halt in the stock Odfjell and the finance inspection in Norway started investigating the case.
The economic crime-authority in Norway then proceeded to accuse Mr Larsen, and Mr Veiby who had also made money on the Timber Hill algorithm, of market manipulation. The trial got a lot of attention in the media and the two Norwegians were portrayed as the heroes who

[11] Mr Manoj Narang founder of Tradeworx featured in `http://www.youtube.com/watch?v=WyPPaiZEYO4`

[12] An article on the matter in Svenska Dagbladet by Björn Lindahl: `http://www.svd.se/naringsliv/manniska-vs-maskin_6627572.svd`

stood up against the machines and beat them in their own game. After 3 years worth of of trials and two appeals, Mr Larsen and Mr Veilby were found innocent.

3.2 Conclusion

The above example illustrates the general consensus regarding HFT. Most people believe that the techniques used by HFT-firms are unethical and should be banned. What most people don't know is that the majority of the strategies are as old as the financial market itself. The new technology used by HFT-firms i.e. direct market access and low latency is a natural development of the digitalization of the financial market. HFT is simply an updated and more efficient version of daytrading. If one finds the strategies to be unethical then the focus should be on regulating all of the market with respect to these types of strategies and not specifically HFT. The most common examples of strategies used by high frequency traders in the media today are the market-manipulative strategies and of course these strategies are unethical and also illegal. We think this might be the cause to the general distrust of HFT by the public today.
A lot of the risks generally connected to HFT are actually rooted in the U.S. market structure[2]. Since the game has changed a lot in the recent decade there needs to be more updated regulations and safety measures regarding the entire market.
As discussed above the literature on whether or not HFT affects the market in a bad way is inconclusive. As a matter of fact most studies show that HFT seems to have a positive effect on the market. Most HFT strategies provide liquidity, reduce the number of arbitrage opportunities, lower the short term volatility and greatly increase the price discovery processes. Hence we believe that regulations should aim to preserve these benefits while making the market more transparent and safe.
In conclusion we want to address a common misconception made by most articles regarding HFT. HFT-algorithms are not machines or robots with minds of their own, they were written and constructed by humans. Humans calibrate and figure out the strategies and implement them to take advantage of the advances in technology to make money on the financial market.

4 Reading guide

Below you will find references and links to interesting papers and articles on HFT. We also include some links to videos with interviews of people that work with HFT that can be of interest.
The foremost research paper which we believe delivers the most unbiased opinion and interesting results is the first one by Gomber et al.

4.1 Research papers

High-Frequency Trading Gomber, Arndt, Lutat, Uhle 2011. [2]

Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market, Chaboud ,Chiquoine, Hjalmarsson, Vega, 2011. [10]

The Flash Crash: Impact of high frequency trading on an electronic market, Kirilenko, Kyle, Samadi, Tuzun, 2011. [7]

4.2 Videos about how HFT works

The first video is a panel discussion with people someway involved in High Frequency Trading.
`http://www.youtube.com/watch?v=WTQGsr_4DPg&feature=related`
The second video contains a very useful short introduction to HFT in the first 12 minutes.
`http://www.youtube.com/watch?v=NzfmT4vGXZY&feature=related`
The third and last video is a CNN-interview of Mr Manoj Narang who is the founder of Tradeworx, an american HFT-firm.
`http://www.youtube.com/watch?v=WyPPaiZEYO4`

4.3 News articles

Article/interview from Wall Street Journal with Jim Simons, hedge fund manager of Renaissance Technologies. [8]

Article from The Bureau of Investigative Journalism in the UK titled: "Robot wars: How high frequency trading changed global markets." [13]

References

[1] Chlistalla M, Speyer B, Kaiser S, Mayer T. High-frequency trading, Better than its reputation?; 2011. Acquired November 2012. http://www.dbresearch.de/PROD/DBR_INTERNET_EN-PROD/PROD0000000000269468.PDF.

[2] Gomber P, Arndt B, Lutat M, Uhle T. High-Frequency Trading; 2011. Acquired November 2012. http://www.frankfurt-main-finance.de/fileadmin/data_archive/de/finanzplatz/daten-studien/studien/High-Frequency-Trading.pdf.

[3] Biais B, Woolley P. High frequency trading; 2011. Manuscript acquired November 2012. http://iucontent.iu.edu.sa/Scholars/Information%20Technology/High%20frequency%20trading%20Bruno%20Biais%20(Toulouse%20School%20of%20Economics).pdf.

[4] Condon N. FINRA Sanctions Trillium Brokerage Services, LLC, Director of Trading, Chief Compliance Officer, and Nine Traders $2.26 Million for Illicit Equities Trading Strategy; 2010. Press release September 13 by FINRA(Financial Industry Regulatory Authority). http://www.finra.org/Newsroom/NewsReleases/2010/P121951.

[5] Mehta N. Dark Pools Win Record Stock Volume as NYSE Trading Slows to 1990s Levels. Bloomberg. 2012;Article written March 1, 2012. Acquired November 2012.

[6] Salmon F. Trillium wasn't quote-stuffing. Reuters, Opinion. 2010;Article written September 14, 2010. Acquired November 2012.

[7] Kirilenko A, Kyle AS, Samadi M, Tuzun T. The Flash Crash: The Impact of High Frequency Trading on an Electronic Market; 2011. Acquired November 2012. http://www.ftm.nl/upload/content/files/Onderzoek%20Flash%20Crash.pdf.

[8] Corkery M. Jim Simons on Flash Crash: High Frequency Traders Saved the Day. Wall Street Journal Blogs, Deal Journal. 2010;Article written September 13, 2010. Acquired November 2012.

[9] Hendershott T, Riordan R. High Frequency Trading and Price Discovery; 2011. Acquired November 2012. http://business.nd.edu/uploadedFiles/Academic_Centers/Study_of_Financial_Regulation/pdf_and_documents/hendershott_hft.pdf.

[10] Chaboud A, Chiquoine B, Hjalmarsson E, Vega C. Rise of the Machines: Algoritmic Trading in the Foreign Exchange Market; 2009. Acquired November 2012. http://www.federalreserve.gov/pubs/IFDP/2009/980/ifdp980.pdf.

[11] Brogaard J. High Frequency Trading and Volatility; 2011. Acquired November 2012. http://www.wsuc3m.com/HFT_and_Volatility_Final%20Brogaard.pdf.

[12] Zhang F. High-Frequency Trading, Stock Volatility, and Price Discovery; 2010. Acquired November 2012. Available at SSRN: http://ssrn.com/abstract=1691679 or urlhttp://dx.doi.org/10.2139/ssrn.1691679.

[13] Ross K A, Mathiasson N, Fitzgibbon W. Robot wars: How high frequency trading changed global markets. The Bureau of Investigative Journalism. 2012;Article written September 16, 2012. Acquired November 2012.