HIGH FREQUENCY TRADING 101: REGULATORY IMPACT IN AMERICAN AND EUROPEAN MARKETS

by
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Abstract

YASMINE ELISABETH ALLEN: HIGH FREQUENCY TRADING 101: REGULATORY IMPACT IN AMERICAN AND EUROPEAN FINANCIAL MARKETS

(under the direction of Bonnie Van Ness)

High frequency trading has impacted the American and European financial markets through its advanced algorithms, rapid speed, and preferential treatment from purchasing information and co-location from exchanges. High frequency trading alone is not harmful, but without proper regulations it can hurt the financial markets. In this thesis, I researched implemented regulations, the consequences of those regulations, and pending new regulations. To gather information, I studied relevant research on the topic, including numerous academic articles and books to get a broader view of the issues. Through my research, I have found that previous regulations implemented by American and European regulatory agencies have benefitted high frequency trading firms, and that exchanges, through selling information via co-location, have created an environment that benefits high frequency traders. High frequency trading firms are affecting the market in a negative way by providing a false sense of liquidity while acting as a market makers and by purchasing preferential information and access to the financial markets.

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CHAPTER I: INTRODUCTION

"The market is like a shattered vase that is now held together with glue called high frequency trading (HFT), and that glue is weak" (Arnuk & Saluzzi, 2012, p. 8).

Deeply-rooted in the U.S and European markets is a predator. That predator is eating from the average person's hard earned money. That predator dominated more than half of the U.S market in 2009 and made over $5 billions in earnings (Serbera & Paumard, 2016). This predator is called high frequency trading. High frequency trading is high speed trading through the use of algorithms to earn advantages in the financial markets based on speed. High frequency traders transact in milliseconds and nanoseconds using advanced computer systems and co-location.

High frequency trading in itself is neither good nor bad, but is a part of the technological advances that have developed during the 20 and 21st centuries. The technology behind high frequency trading is not unique to the stock market, technological advances are happening in all industries across the world. With new technology comes new guidelines that one has to follow for the markets to function properly. High frequency traders must, as Ted Kaufman explains in Broken Markets (Arnuk & Saluzzi, 2012), operate within a framework. Appropriate framework is where high frequency trading is lacking and where the correct regulations must be implemented to help set things straight. New innovations and technological advances are detrimental to future

growth and development (Bréhier, 2013). High frequency trading is the result of these new innovations mixed with legislative actions that allowed high frequency trading firms to become the massive trading machines they are today.

According to Patterson (2012) in August 2008 around 90 percent or more of the orders that entered the market were canceled, and in the time frame, from 2009-2011, 60 percent of orders were canceled within one second (Gregoriou, 2015). The speed at which high frequency traders entered and canceled orders was automated and could not be accomplished or even noticed by humans. The problem might not lie in the fact that computers trade fast and with accuracy (Bodie, Kane & Marcus, 2014), but the fact that the US exchange system is not built for this type of trading (Patterson). The US stock market had become a complex system but was still operating on a simple platform.

High frequency trading is a huge source of profits. High frequency trading firms rarely hold positions overnight and work more as market makers than traders (Patterson, 2012). High frequency trading firms are different from traditional market makers in that they are not regulated and registered as market makers, they operate freely and without most traders' knowledge (Lewis, 2014). That high frequency trading is complex and hard to understand is something on which most everyone who has heard about it agrees. In this thesis I will discuss how high frequency trading affects the legal and economic realms in America and Europe. From a legal perspective, the government and regulatory authorities have to decide which laws to implement to ensure safe and efficient markets. As discussed later in this thesis, regulations can also hurt the market if not implemented correctly. High frequency trading affects the economy of a country through how it affects the trust of the everyday investor.

CHAPTER II: HIGH FREQUENCY TRADING

Technological advancement with high frequency trading started back in the 1990's (Patterson, 2012) and has continued growing and developing in the stock market since then. Wall Street is no longer what it was in the 80's. Trading floors hardly exist anymore because the human capacity to trade is no longer sufficient in the technological driven world we live in today. High frequency traders trade through computer algorithms instead of specialists. Dating back to 1997 when IBM's robot Deep Blue beat the world chess champion in chess (International Business Machines Corporation [IBM]), we have known that computers can out speed and outsmart the human brain in certain tasks. In the case of high frequency trading, computers have done just that. High frequency trading firms transact at a speed much faster than a human eye can blink and they are trading faster than a regular investor with a computer with high-speed Internet could ever achieve. According to Gregoriou (2015) high frequency trading is "the use of propriety trading algorithms which are executed with the help of superfast computers to make a profit on the basis of informational speed advantage measured in milliseconds; rapid entry and exit from the order stream may fetch a small fractional profit but the large volume turns that into substantial sums for the HF traders." (p. 113)

A. U.S. STOCK MARKET HISTORY

In 1792, 24 brokers came together outside 68 Wall Street in New York to sign the Buttonwood Agreement to begin trading securities (The New York Stock Exchange [NYSE]). Since then, the NYSE has been an ever evolving market. Many more exchanges have come into existence. Some of them, like BATS, started in 2005 (Bats Exchange), serve as alternatives to the more traditional exchanges, such as the NYSE and NASDAQ.

Although the theoretical purpose of US Stock markets, to efficiently bring together buyers and sellers, has not changed, the day-to-day working reality has changed since the opening of NYSE in 1792. Today, most exchanges are for-profit companies and these companies make more money for their shareholders when traders, for instance, high frequency traders, use their venues to trade. Profit-driven exchanges' priorities are no longer the everyday long-term investor, but instead their priorities lie with the traders generating the most income for their shareholders. Hence, these exchanges cater to the high frequency traders. It is not possible, nor plausible, for human investors to trade the same volume as a high frequency trading firm and it is not feasible for most investors to pay for preferential access via co-location, which means that the for-profit exchanges would lose money if they catered to long-term investors

B. ALGORITHMIC TRADING

Algorithmic trading started in the 90's (Bréhier, 2013) and has, like many other technologies grown and expanded at a rapid speed. Algorithmic trading has grown to become half of the US equity market (Bodie, Kane & Marcus, 2014). There are many different forms of algorithmic trading, some use algorithms to detect news updates and

others use algorithms to detect price discrepancies. Algorithms can scan news releases and use artificial intelligence to interpret the news and employ algorithms to determine the best trading strategy based on the information from the news. Algorithmic trading can be used to correct price discrepancies between two exchanges. When prices on different exchanges do not match up, algorithms can choose to buy or sell stock to take advantage of the price discrepancy. Algorithmic trading is only going to increase as we move forward in the 21st century. Another type of algorithmic trading is high frequency trading. High frequency trading uses mathematical algorithms to determine what trade to make and to execute that trade at an extremely rapid speed to earn very small profits per trade.

According to Harris (2013) several reliable studies have shown that transaction cost has decreased since algorithmic trading became part of the financial markets. The decrease in transaction cost is due to the fact that computers have advantages over human traders in that they have seamless attention spans, follow instructions precisely as told, do not let any emotions cloud or act on their judgment, can learn and watch thousands of different sources for information at the same time, do not cheat, cost less than their human counterpart, and they do not require as much office space. (Harris)

Harris (2013) describes the different categories of algorithmic trading: The first category is called dealing and arbitrage and according to the article it is the most common form of algorithmic trading. Dealing and arbitrage adds value to the market through offering liquidity, or moving liquidity to and from different markets. Another category that Harris discussed monitors newsfeeds for information regarding particular firms. These algorithms monitor newsfeeds and interpret and trade on the news based on the data collected. To lose to someone who is better informed, is nothing new, however many

people dislike the idea that they lose only because they cannot act as quickly as algorithmic traders can about fundamental news events. (Harris)

C. HIGH FREQUENCY TRADING HISTORY

Humans have and hopefully always will try to come up with new innovations to improve their existence. When the Internet began in the 1980's the world began to change, and the stock market followed this trend. The desire to build faster, more powerful computers, and to use more complex and extensive programming started when investment companies and the exchanges realized how much money there was to be made in the high frequency trading business. (Patterson, 2012)

High frequency trading started earlier than what most would assume, in the 1990's (Patterson, 2012). Early high frequency trading was simple computer trading operations linking to an exchange. Due to regulations, such as Regulation alternative trading systems (Reg ATS) and Regulation national market system (Reg NMS), and advances in technology, high frequency traders were able to grow and become the powerful and fast machines that they are today.

Before the aforementioned regulations came into place, a company by the name of Instinet was using an alternative trading system to trade. Instinet users would frequently place I-Only orders to trade (Arnuk & Saluzzi, 2012). I-Only orders were popular as these orders were seen by only institutional investors. I-only orders were large in size but as they were only seen by other institutions wanting to transact in large quantities, I-only orders did not move the price when executed. Instinet offered I-only since the firm did not believe that one market was made for all different types of trading (Arnuk & Saluzzi). When Reg ATS was implemented, Instinet became a dominant ECN (Arnuk & Saluzzi).

ECNs are Electronic Communication Networks and they have the benefit of anonymously matching buyer and seller, without the need of human intervention (Bodie, Kane & Marcus, 2014). Although matching could be done anonymously, the passage of Reg ATS required Instinet to display its private quotes—its I-only orders. According to Arnuk & Saluzzi, Reg ATS was created, more or less, to stop I-only orders. The stopping of I-only orders through Reg ATS was the first real start to high frequency trader's major take-over of the U.S. markets (Arnuk & Saluzzi). Reg ATS added more transparency in an attempt to make the market fairer as more traders could see more quotes. But, some of the traders benefiting from that transparency included high frequency traders. A revolution of algorithmic trading had begun, thanks to the regulations implemented by the SEC, high frequency traders had not only survived because of their strategies using advanced algorithms, but also because various exchanges and SEC regulations helped them. According to Patterson (2012), this help included the SEC putting the interests of high frequency traders above all other participants in the market through regulation, and caused the creation of the mechanism that high frequency traders needed to succeed.

Just a little over a decade ago, most stocks were traded by a broker on the NYSE or NASDAQ. In ten years the markets have rapidly changed. Just over ten years ago, the SEC required all US stock markets to switch to the decimal system. Spreads became smaller very quickly as did the trade sizes and quoted depth. Because of the regulation, high frequency trading started growing even more, and by 2009 high frequency traders had 70% of the market (Arnuk & Saluzzi, 2012). With the growth of high frequency trading came more structure risk. A smaller spread and smaller trade sizes fueled the growth of high frequency trading firms. A high frequency trader is a short term trader in

its truest form, high frequency traders transact large quantities of small trades, instead of having fewer, but larger trades.

Reg NMS was implemented in 2007 (U.S. Securities and Exchange Commission) and mandated the current rules for disseminating the national best bid and offer (NBBO). The NBBO is the national best bid and offer from all trading venues. With Reg NMS, an order is automatically routed to the exchange with the best price, even if that means that the entire order will not be filled on that one exchange.

Technological advances have made the markets operate faster and more efficiently. The main problem is not how to get rid of high frequency trading, but how to embrace technology and at the same time have it under control.

D. HIGH FREQUENCY TRADING METHODS

High frequency trading works in different ways depending on the type of high frequency trading and the goals of high frequency traders. The basic concept of high frequency trading is to use a network of computers co-located at the various exchanges to trade. Because the system uses algorithms to trade, it can execute the trades faster than a human can blink. It can do so as computers are not affected by emotions and feelings, and computers have advanced processing software already built in. Humans must process the information and make a decision to trade, which takes far longer. Computers compared to human traders are also able to simultaneously gather information from a large scope of information sources. The computers can then process that information faster than regular investors, all the while making trading decisions, which causes the high frequency traders to enter and cancel orders based on the new information received. A regular trader would have great difficulty keeping track of so much information at

once. That computers have the above stated advantages can be both negative and positive. The positive includes that the way we trade becomes more efficient as the use of computers and technology increases, the cost gets lower as technology is expanded, and we no longer need as much human capital since computers can now take over many of the jobs of humans. On the other hand, the financial markets are not regulated well enough for computers to function without human intervention. An unfair market is not to any institutional or human investor's advantage, and the institutional investors are the ones investing capital into the market.

Unlike human traders who buy and sell securities based on fundamental or technical information, high frequency trading firms buy and sell based on speed and information gained through co-located servers. High frequency traders purchase preferential access to the exchanges, and hence the order and trade information of the exchange, via co-location, which implicitly hurts the retail investor who does not have this advantage. High frequency traders make money by beating other traders to the trade. High frequency traders are not like regular investors as they do not care about the security they trade since they will not hold on to it for long (Gregoriou, 2015). If a stock broker enters an order to sell 1000 shares of XYZ company, the high frequency trading firm's co-located computer detects that the order has been entered and will execute. The high frequency trading firm, using its speed and co-located servers, beats the stock broker to another exchange, buys the XYZ stock, and then sells it to the broker for a higher price. The regular investor would lose "only" a few cents per trade, which to most investors is not a huge loss. That is why it took so long for the market to discover what high frequency traders were doing. High frequency trading firms were making a lot of

money on earning a few cents from a large number of investors. The average return that a high frequency trader makes on one transaction is $5.05 (Goldstein, Kumar & Graves, 2014). A high frequency trading firm that 'front runs' had gross trading profits of $45,267 per day in 2010, compared to gross profits of $2,461 per day for a firm that does not front run (Goldstein, Kumar & Graves) If one investor lost the same amount that high frequency traders made, the practice would have been noticed sooner.

When discussing what high frequency traders are doing to hurt the market, the term front running is widely used (Harris, 2013). Front running is discussed in the book Flash Boys by Michal Lewis (2014). High frequency traders are front running non-high frequency traders and thus make non-high frequency traders' trades more expensive. There are two types of front runners according to Harris:

1) Order anticipation is when high frequency traders anticipate what order the trader will submit. High frequency traders are able to anticipate an order by using algorithms to examine previous orders and trades to predict when a trader will split up a large order. High frequency trading firms will then trade ahead of the trader with their faster co-located computers and profit from the price change they initiate.

2) Quote matching refers to standing orders that have already been posted. High frequency trading firms simply trade ahead of orders and increase the price slightly or trade in another venue. When prices change in favor of high frequency traders, they profit, and when it does not, high frequency traders immediately exit their orders by trading with standing limit orders. "They profit by extracting option values from standing limit orders submitted by slower traders" (Harris, 2013, p.7). Quote matching causes

problems since the trader who originally issued the standing order is forced to trade when they do not want to and fail to trade when they wish to. (Harris)

Other tactics that the high frequency traders use are quote stuffing, spoofing and momentum ignition (Gregoriou, 2015). Quote stuffing is when the high frequency firms enter and immediately cancel a multitude of orders for a security. High frequency trading firms enter a multitude of orders to slow down competition. When quotes are entered, whether reasonably near the best bid or offer or far away from the best prices, other traders have to analyze these quotes, which creates an advantage for the high frequency trading firm that placed the orders. Spoofing is when one trader is teasing information from other traders by placing and canceling orders (Pandey & Wu, 2015) Placing "fake" orders to move the price in a particular direction is illegal (U.S. Securities and Exchange Commission), but it can be hard to prove. Momentum ignition is when a high frequency firm enters orders, sometimes in combination with spreading false rumors, to make other traders start trading more rapidly to make the price move up or down faster. All of these different strategies are on the verge of being illegal, but hard to prove as they are done at such rapid speed.

E. HIGH FREQUENCY TRADING ORIGINS

We live in a technology driven society where companies and people strive to be as effective and efficient as possible. It is human nature to develop innovations to make life easier, cheaper, more efficient, etc. Trading in the security markets is no different. Using computers to trade instead of humans was more a question about when than why and how. In the book, Dark pools, Scott Patterson (2012) discusses how the value of computer programmers has increased in the stock market. Using algorithms to trade is not

a problem in itself, even algorithmic trading with very rapid speed is not a problem. The problem, or the reason high frequency trading is the widely debated topic that it is today, is due to profit driven traders coupled with regulation that enables these traders to take advantage of others.

When high frequency trading, as we know it today, started it was kept in the dark, it was secret. And no wonder, since the people who started it were sitting on a gold mine. The book flash boys (Lewis, 2014) discusses how a company, Spread Networks, wanted to lay a fiber optic cable line between Chicago and New York. The cable was 825 miles long and the price tag was $300-million (Gregoriou, 2015). According to Lewis, no one understood why a company wanted to spend all that money on a cable that would run straight from New York to Chicago; and when an outsider asked, he was told it was a secret project (Lewis). The reason why the line was so important was because high frequency trading firms compete on speed, and by having a straight optical cable between the exchanges, a firm buying space on that cable could win the game—make the distance faster, which would generate higher profits. If other firms knew about the high speed cable, they would want in and would compete at the same speed. High frequency trading only works for the company that is the fastest. High frequency trading companies compete using co-location to gain speed as well. Co-location is the term for having a firm's computer located in the same facility as the exchange's matching engine. Being co-located means that a company can have access to the exchange's data—trade and quote information—faster as the firm will not have to wait for the information to travel through the public feed. To a regular person, co-location seems ridiculous, but to a high frequency trader, it is everything, it can be all about who is a millisecond faster.

F. DARK POOLS

Dark pools originated for investors that wanted anonymity when trading large orders. When the financial markets started to change due to all the rules and regulations implemented by the SEC, especially with Reg NMS, it became hard for investors to trade larger blocks of stocks without moving the price in the market due to high frequency trading front running them (Arnuk & Saluzzi, 2012) In response to the new regulations the exchanges and some investment banks created dark pools, where the bid and ask prices were hidden and the pool, theoretically, offered full anonymity. Since the orders submitted to the dark pools were hidden, and only invited investors could trade in the pool, high frequency traders could not view these orders. Dark pools also benefited large traders since orders submitted and executed did not dramatically affect the price of the stock. If an investor is selling a large order of stocks he/she does not want to move the price too much since that means less money for the investor who is trying to sell the stock.

Stock Exchanges, brokers, and owners of automated trading systems, according to Arnuk and Saluzzi (2012), have helped high frequency traders receive access to dark pools. One example of high frequency traders having access to dark pools happened in 2011 with Pipeline. According to Arnuk and Saluzzi, Pipeline had secretly traded against their own investors. In Flash Boys, Lewis (2014) discussed that several investment banks and financial institutions allowed high frequency traders to enter their dark pools. Lewis provides more proof of how large financial institutions were using dark pools as a means to earn more money. Since high frequency traders submit such large amounts of orders, the financial institutions that allow high frequency traders to use their dark pools to trade,

earn more money by charging fees to grant access to high frequency trading firms. Allowing high frequency traders access to the dark pool creates a conflict of interest between the organization who owns the dark pool and the institutional investor who uses it. The conflict of interest is particularly troubling when an institutional investor with a large position in a stock chose to trade in a dark pool to protect their position and the corresponding orders from high frequency traders, and pays the company that owns the dark pool for access to trade in it. At the same time, the owners of the same dark pool are also charging high frequency traders to be allowed to trade in the dark pool with the institutional investor. A dark pool earns money when trades are executed in the pool (Patterson, 2012). Dark pools allow high frequency trading firms access as they are supplying such large quantities of orders, and the larger the number of orders submitted to a particular pool, the higher the probability that orders will execute in that pool.

CHAPTER III: THE IMPACT OF HIGH FREQUENCY TRADING ON THE STOCK MARKET

In the not too distant past, market makers were either specialists (on the NYSE) or dealers (on NASDAQ) who were acting as liquidity providers to the financial markets and benefiting from the market maker's spread. Now, according to the Guilbaud and Pham (2013), any market participant can act as a market maker because of the rise of electronic trading. The ease of acting as a liquidity provider has created competition in liquidity provision in the financial markets. This competition has reduced effective market spreads and reduced indirect cost (Guilbaud & Pham). High frequency traders act as market makers as they constantly submit and cancel orders. High frequency traders may detect when an order is placed and partially executed at one exchange, but not fulfilled at that exchange. With high speed, the high frequency trader, can reach another exchange with the next NBBO price, purchase the stock, raise price slightly, sell it back to the original investor who entered the order, and pocket the different prices, or spread, between the two prices. Even though the aforementioned order would likely have been filled as it worked through the posted liquidity on the various exchanges, the high frequency trader is considered to be acting like a market maker in the sense that it provided liquidity to the unfulfilled portion of the order. However, high frequency traders are not under the same obligations as a traditional market maker regarding when or how much liquidity must be provided. Proponents of high frequency trading see it as a

way to increase liquidity and efficiency in the financial markets. Those who are opposed see high frequency trading as an extra cost on a market that is already efficient, adding another middle man. (Patterson, 2012)

High frequency trading firms turned to leverage to maximize profits. According to Patterson (2012) in the late 2000's, high frequency firms were leveraged with a ratio from 50 to 1. High frequency traders were able to become so highly leveraged as they were turning profits almost every day (Patterson), which cause banks and other investors to trust high frequency trading firms with their money.

Another reasonably recent innovation in financial markets is the maker/taker system (Gregoriou, 2015). This system is used by many exchanges and trading venues. Although the maker/taker rebates/fees vary from exchange to exchange, the most frequently used system pays (rebates) a trader who provides liquidity and charges a fee to the trader who takes liquidity (Gregoriou). Since the fee charged for taking liquidity is necessarily larger that the rebate provided to the liquidity provider, the exchange where the trade takes place pockets the difference. The more liquidity supplying orders that are entered at a particular venue, the higher the probability that one of those orders execute and provide liquidity to a liquidity demanding order. The exchanges earn more money the more trades that execute at their exchanges–they pocket more differences between the make and take amounts. Hence, high frequency traders receive special privileges as they submit a large quantity of orders to the exchanges (Arnuk & Saluzzi, 2012). Some exchanges increase the maker rebate for traders who transaction a higher quantity of trades at their venue (Patterson, 2012). Another privilege that high frequency traders pay for, which is also a problem to the regular investor, is

preferential access via co-location. Exchanges have an incentive to sell preferential access to the exchange's trade and quote information since exchanges earn money from co-location fees. High frequency traders are willing to pay for co-location since the closer a firm's co-located computer is to the exchange's main computer terminal, the faster the co-located firm gets the information and the shorter the distance the co-located firm's algorithmic orders need to travel, which gives the co-located high frequency trading firm an advantage in the speed game. To illustrate the outcome of winning at the speed game, one high frequency trading firm reported that it had gone four years without a loss for the day (Lewis, 2014).

At the same time that high frequency trading firms are earning more money by being faster to the trade, the exchanges are also earning more money. The exchanges that are not selling co-location are not. High frequency firms submit orders where they have the best advantage, which include faster execution and better information via co-location. Exchanges not selling co-location will not receive the large quantity of orders from high frequency traders, hence will likely not be executing the same quantity of trades. Not allowing co-location are causing the investors at exchanges that do not allow co-location to have higher trading costs since their orders cannot be executed at the best price (Pandey & Wu, 2015). The conflict of interest, selling co-location to high frequency traders, continues as for-profit exchanges must cater to the traders who supply them with the most profits (Arnuk & Saluzzi, 2012).

High frequency trading firms also gain an advantage through purchasing information about firms' financial reports before other institutional investors. High frequency trading firms may purchase the financial report directly from the same provider

that will send out this information to other business sources, who then will release them to the public investor (Gregoriou, 2015). Gregoriou discusses an example where a high frequency trading firm purchased access to the financial report of a company named ULTA. On December 5th 2013 ULTA's stock price dropped rapidly because high frequency traders received information about ULTA's earnings milliseconds before it reached the public, and started trading on the information. High frequency traders sold $800,000 worth of stock in those milliseconds. The institutional investors who received the news milliseconds later were already starting out trading at a loss as the price of the stock had already dropped by the time they were able to react to the information from the financial report.

A. LIQUIDITY PROBLEMS

Another debated topic is whether or not high frequency traders supply liquidity to the market. High frequency traders may supply liquidity in the sense that they are entering and executing large quantities of orders. According to Gregoriou (2015) liquidity is the fine balance and combination of systemic liquidity in market stress and search liquidity in a normal market. Liquidity in market stress is liquidity that is provided when the market is going down and search liquidity is liquidity that is provided in a stable and efficient market. High frequency trading does not meet both of these liquidity requirement since high frequency traders are not required to provide liquidity in market stress (Gregoriou).

By increasing the speed at which orders can be placed and canceled, an illusion of liquidity is created (Patterson, 2012). Liquidity, the ease with which one can convert an asset to cash, without suffering a loss, is important to investors. When a stock is liquid,

investors can enter the market (buy stock) and feel confident that they can sell the stock without losing a lot of money. Liquid markets make investors comfortable to take more risk (Patterson)**.** Bréhier (2013) states, "Some studies conclude that it [high frequency traders] provides liquidity to markets", when, in reality, high frequency traders provide false liquidity (Lewis, 2014; and Patterson, 2012). High frequency traders buy and sell large quantity of shares every day as long as the markets are in their favor. In downturns, high frequency traders do not provide liquidity, they instead take and demand the little liquidity that is left in the market. (Arnuk & Saluzzi, 2012). Going from increments of $1/8 and $1/16 to a 100 decimal point system in the stock market caused limit orders to be less clustered, and price quotes to become thinner and spread out (Arnuk & Saluzzi,).

A lack of liquidity may be a problem when the public loses trust in the market. More than $250 billion dollars have been withdrawn from domestic equity mutual funds in the United States since 2010 (Arnuk & Saluzzi, 2012). Because of withdrawn money in domestic equity mutual funds, the economy as a whole can suffer since companies depend on the financial markets as a way of raising capital (Arnuk & Saluzzi). According to Arnuk and Saluzzi, liquidity in the market was more stable and easier to predict when long term investors were the source of liquidity. The liquidity provided was "real", unlike the liquidity provided by high frequency traders, which is not. According to Bréhier (2013) there are two different types of liquidity to be considered. There is "natural liquidity", which is what the economic players provide to the market, and there is "liquidity of opportunity", which is what is provided when a trader takes a tactical position. Liquidity of opportunity currently accounts for 80% of the market, and it is the category of liquidity provided by high frequency traders.

B. COST

The few cents that an institutional investor loses when large orders are executed at different prices as the order moves from exchange to exchange getting partial executions along the way do not, generally, add up to a large sum of money. However, when considering the large number of trades that are being partially executed at multiple exchanges by high frequency trading firms, the profits that high frequency trading firms are making becomes large. Patterson (2012) describes the situation in the book, Dark Pools, as follows: when you lose money in a mutual fund due to high frequency traders front-running you, even if it is not a considerable amount, it is money that you can no longer reinvest in the market. That reinvestment value will add up if calculated over a long period of time and it turns out to be a large sum of money that an institutional investor could have saved, but failed to do so due to high frequency trading.

C. FLASH CRASH

The flash crash occurred on May 6th 2010. According to SEC's website, the equity market had a severe disturbance that occurred in the matter of minutes. A large number of securities started to decline rapidly and then started to increase again once the problem was located. The fast shift and high volatility in prices did not go unnoticed by the market. A lot of trades were executed at a severely low prices. According to the SEC, "including many that were more than 60% away from pre-decline prices and were broken by the exchanges and FINRA" (U.S. Securities and Exchange Commission [SEC]). The Dow Jones average fell by 1,000 points for the day, and it fell by 583 points within seven minutes (Arnuk & Saluzzi, 2012).

High frequency trading was part of the flash crash according to Arnuk and Saluzzi (2012). When the flash crash started and the Dow Jones started to drop rapidly; a human trader could detect that something was fundamentally wrong, but a computer working via algorithms could not. Goldstein, Kumar and Graves (2014) state that high frequency traders kept pushing down the prices by aggressively selling what stock they currently owned, which meant that trading volume increased for high frequency traders. When the volume increased, volatility increased, which prompted long term investors to withdraw from the market and left high frequency traders to compete with themselves. Eventually, high frequency traders backed out too and liquidity in the market plummeted further. The reason why liquidity disappeared is because the "liquidity" provided by high frequency traders is provided only when the markets are normal (Gregoriou, 2015). When the markets start to shift, and volatility increases, high frequency traders "take" the liquidity. When the source of the flash crash was discovered, the market started to bounce back.

According to Bodie, Kane, and Marcus (2014), the SEC approved circuit breakers to prevent this type of algorithmic malfunction in the future. If a stock increases or decreases more than 10% within a 5-minute period, the circuit breaker will halt trading. The circuit breaker rule was implemented in a series of stages (Bodie, Kane & Marcus).

In March 2016, a man named Navinder Sarao was charged by the court in England to be extradited to the United States since he allegedly played a role in the flash crash. According to Forbes, Sarao used spoofing to earn an advantage and money in the U.S. market (Gara, 2016). Spoofing is illegal and as stated above in this thesis, spoofing is when one trader is teasing information from other traders by placing and canceling fake orders. Although the flash crash happened five years ago, who or what caused the flash

crash is still uncertain. Most sources agree that algorithmic trading had some part in it (Goldstein, Kumar & Graves, 2014), and that it brought attention to the fragile U.S. market (Bodie, Kane & Marcus, 2014).

D. HIGH FREQUENCY TRADING BENEFITS

Brogaard, Hendershott, Hunt & Ysusi (2014) relay that most academic research points towards high frequency trading having improved measures of financial market quality such as volatility and liquidity. Menkveld (2013) claims that high frequency trading firms decrease the spread by 50%. Carrion (2013) claims that when spreads are wide high frequency trading firms provide liquidity. However, Brogaard, Hendershott, Hunt and Ysusi claims that liquidity might only help a few investors, but not institutional investor. Gregoriou (2015) states that regardless if high frequency traders have provided real liquidity or not, they have helped narrow the spread, which is beneficial to all investors since the fees paid by investors are not as high. However, Gregoriou fails to mention what happens to the traditional market makers when unregulated high frequency traders take their place. Bréhier (2013) states that because high frequency traders have taken over the roles of traditional market makers, they have encouraged market transparency, as well as helped the overall economy by providing additional liquidity, since it will become easier for a company to obtain capital for investments. As described earlier in the thesis, high frequency traders supply a false sort of liquidity that is beneficial only when markets are running smoothly. Just because studies show that market liquidity has improved in the last few years, it does not mean that high frequency traders are responsible for the improvement. Regulations, such as Reg NMS, may have helped with improving market liquidity (Bréhier)

CHAPTER IV: CURRENT REGULATIONS REGARDING HIGH FREQUENCY TRADING

"The mission of the SEC is to protect investors; maintain fair, orderly, and efficient markets; and facilitate capital formation. The SEC strives to promote a market environment that is worthy of the public's trust"(U.S. Securities and Exchange Commission[SEC]). The SEC must be careful not to harm the markets when considering new legislative action. Tough regulations may stifle market advances and innovations, which are two drivers for competition (Bréhier, 2013).

A. U.S. MARKET

Regulation has helped pave the way for high frequency trading in both U.S. and European markets (Gregoriou, 2015). In 1998, the SEC approved Regulation Alternative Trading Systems (Reg ATS)(U.S. Securities and Exchange Commission). Reg ATS was implemented to regulate a new method used to trade: Electronic communication networks (ECNs). The SEC wanted to add more transparency to the markets. Through Reg ATS, most ECNs were forced to show all of their orders to the public. According to Arnuk and Saluzzi (2012), Reg ATS "required alternative trading systems that trade 5 percent or more of the volume in national market system securities to be linked with a registered market in order to disseminate the best priced orders in those national market system securities displayed in their systems (including institutional orders) into the public quote stream"(p. 69). The SEC succeeded in adding more transparency, but the added transparency helped high frequency trading firms succeed.

Nanex showed that the national best bid and offer spread did not narrow after the government imposed Regulation National Market System (Reg NMS) in 2007 (Pandey & Wu, 2015). Reg NMS was to help promote fair price competition. Instead of helping the market, Reg NMS had unintended consequences according to Lewis (2014). All that Reg NMS has done is give the illusion of liquidity to the market (Pandey & Wu).

In August 2000, all stocks started trading on a 100-point decimal system (Arnuk & Saluzzi, 2012). According to Arnuk and Saluzzi, one flaw in Reg NMS is the lack of a minimum spread or price increment. When pricing changed from$1/8 and $1/16 to decimals, it became easier for high frequency traders to step in front of other's orders, since it required only a penny to do so.

Reg NMS also stipulated that an order to buy or sell a stock had to be routed to the venue with the best posted price. So, a stock that normally would have traded on the NYSE now had to go to the exchange with the best price, even if that meant that the order had to be executed at several different exchanges. Depth at the best price decreased with decimalization. So, a large order would, most likely, partially execute on multiple exchanges since, by law, the order had to be routed to the venue with the best price even if the depth at the best price was not sufficient to cover the order. Inadvertently, Reg NMS made speed extremely important. The trader who could get an order to the exchange with the lowest price first would be able to obtain that price. Since high frequency traders were the fastest traders in the markets, they were able to detect the large order, trade ahead of the partially-filled order, instantaneously submit an order at a slightly improved price (in other words, become the next best price) to then trade with the

partially-filled large order at a profit. Reg NMS enhanced high frequency trading firms' front running techniques.

Further, Reg NMS also drove many market makers, who dealt with small and mid-cap stocks, out of business due to margin compressions (Arnuk & Saluzzi, 2012). Arnuk and Saluzzi state that previous market makers were required to provide liquidity in the market (when there was no liquidity) and to withdraw liquidity (when liquidity was too high) to help regulate the market and decrease inventory risk. High frequency traders, with high volume of order submissions, took the place of traditional market makers, but without the associated rules and regulations. When liquidity was plentiful, high frequency traders traded more, which further increased liquidity. When liquidity was low, high frequency traders withdrew from the markets, thus decreasing liquidity even more.

Average trade size decreased with high frequency traders (in conjunction with Reg NMS) as large orders had to be routed from exchange to exchange partially filling at each best price. Partial execution at the best price allowed high frequency trader to front run partially-filled orders and grab a chunk of the profits. Traditional market makers are not allowed to front run orders since they have a negative obligation (Gregoriou, 2015). Having a negative obligation means that market makers are not allowed to interfere with the market for their own personal gain if the markets are efficient enough that buyers and sellers match up (Investopedia, 2003).

The reason as to why the SEC implemented regulations, such as Reg ATS and Reg NMS, have been questioned by many. One thing is certain and that is if not for these regulations high frequency trading would not have been what it is today (Arnuk & Saluzzi, 2012). The U.S stock market was long known as the greatest in the world, and a

big part of the American dream. “Reg ATS killed the goose that laid the golden egg of a U.S stock market that the rest of the world envied for its capacity to embrace risk and drive entrepreneurship and innovation in ways that gave birth to entire new industries and drove U.S economic leadership.” (Arnuk & Saluzzi, p. 202)

B. LULD PLAN

One common measure of market risk is volatility. During the Flash Crash, volatility increased significantly. The Limit Up/Limit Down (LULD) Plan was created to prevent high volatility in the stock market (FINRA, 2012). The LULD Plan was filed by FINRA in 2012 to try to ensure that the markets were kept fair and orderly. According to FINRA’s website, the LULD Plan should prevent the kind of volatile price movements that happened during the flash crash in May 2010.

C. EUROPE/SWEDEN

High frequency trading in the London Stock Exchange is not much different than in American exchanges. Current European regulations (as of July 2010) do not require all high frequency traders to file transaction reports, and do not require high frequency traders to be registered under the markets in financial instruments directive (MiFID) (Brogaard, Hendershott, Hunt & Ysusi, 2014). The rapid changes in financial markets and time required to pass and implement regulations exist in European markets as well as U.S. ones. MiFID 1 was implemented in 2007 (Bréhier, 2013), but in 2012 it was already starting to be revised. MiFID 1 was European markets’ Reg ATS. The directive opened up competition with technology in the markets (Gregoriou, 2015).

MiFID II, which applies to all member states within the European Union, was passed in 2014. Regulations from MiFID II deal with the rise of high frequency trading as

well as algorithmic trading (THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, 2014). European legislators are making a clear distinction between algorithmic trading and high frequency trading to better help the market when regulating it. MiFID II states that any person who is dealing with high frequency trading falls under the rules and regulations set forth by MiFID II (Gregoriou, 2015). MiFID II states that all high frequency trading firms have to register, have to keep records about all orders placed, cancelled and executed, and that all records need to be available for the authorities upon request to make sure that the proper regulations are followed (Gregoriou). MiFID II also states that any investment firm participating in algorithmic trading and taking a market making strategy has to enter into a written agreement to carry out the market making position and provide liquidity. Lastly, MiFID II states that the regulated European markets have to perform tests of existing algorithms in their markets and limit the ratio of unexecuted orders. Because of these regulations, it will be easier to detect system capacity being strained, and MiFID II will help the regulated European markets slow the order flow if system capacity is strained (Gregoriou). The regulated European markets also have to ensure that are no incentives to encourage disorderly trading or market abuse. MiFID II requires fees on canceled orders based on how long they were in force. A fee on canceled orders will impede high frequency traders who submit large quantities of orders that are in force for less than one second. According to Gregoriou, the regulated European markets may also have to impose even higher fees on high frequency traders that constantly cancel and hold orders for a short period of time, which would further hurt those traders that put a strain on the financial system.

The same problem that is happening in the American markets, regarding investors losing their trust in the markets, is happening in the Swedish market as well. When high frequency traders are able to trade at a rapid speed and in such large quantities, investors have no method to keep up with that competition, neither do investors have enough money to buy fast trading computers (Finansliv, 2015). Finansliv.se interviewed Per H Börjesson who is CEO for Investment AB Spiltan, Börjesson believes that if this trend with high frequency traders taking over the market and having preferential treatments within the exchanges continue to happening, the investors will leave the markets. This is a trend discussed earlier in this paper that is happening in the United States as well. When investors lose their faith in the market, with no hope to regain it, they stop investing.

Sveriges Radio interviewed Björn Hagström, an Associate Professor of Finance at Stockholm University, in a radio show called "Robotar tar över ekonomin". In the interview Hagström claims that the different types of high frequency traders matter and that different algorithms exist for the different types of trading. As has been stressed prior in this thesis, high frequency traders are not long-term investors, who are buying the stock because they analyzed the company and want to take part in the future of the company—both the profits and risk associated with stock ownership. According to Hagström, high frequency traders do not care what they buy, they buy these stocks on the Swedish exchange only to earn easy money.

CHAPTER V: HIGH FREQUENCY TRADING: THOSE TO BLAME

How did high frequency trading grow to be such a dominant player in financial markets? To quote former senator Ted Kauffman, “It is simply a truism that whenever there is a lot of money surging into a risky area, where change in the market is dramatic, where there is no transparency and therefore no effective regulation, we have a prescription for disaster” (Arnuk & Saluzzi, 2012, p. Xii).

If what Kauffman states is true, is there an entity to fault for the problems associated with high frequency traders in the financial markets? Is it the high frequency trading firms who have taken advantage of the opportunity created for them, or the entities who created the opportunity? The answer is both. Most of the discussion regarding high frequency trading has focused on the negatives of high frequency trading, include most of my sources for this thesis. The U.S. government through is regulation did not do enough to prevent the issues with high frequency trading firms. Rather, the government instituted regulations to help it. If the SEC is constantly lagging the new technology, new regulations will not be effective. Further, it does not work for regulations to take over five years to be passed and implemented in a rapidly changing technology market. If the regulators are addressing a problem that came about five years ago, the technologically advanced companies are already five years ahead in their new trading techniques. The argument made by Bréhier (2013) is as follows: ”Professor Jean Hilaire concludes that the entire history of stock exchanges is dominated by prohibitions which are continuously being circumvented” (Bréhier, p. 71). We need faster and more

efficient solutions to the problem at hand so that the regulations are not circumvented by the time they become effective.

CHAPTER VI: IEX STOCK EXCHANGE

The Investors' Exchange, IEX, was founded because of the unfair advantages on other trading venues. According to the book Flash boys by Michael Lewis (2014), IEX was started by Brad Katsuyama because he believed that the U.S. stock market was rigged. Most trading venues allow high frequency traders to purchase preferential access to the venue via co-location. High frequency traders profit through co-location and the trading venues share in the profits as well by executing a larger share of market trades. According to Brad Katsuyama, preferential access created unfair practices, which led to the stock market being rigged. He quit his job as Global Head of Electronic Sales and Trading at RBC Capital Markets and started a new trading venue together with other experienced people in the financial industry. In August of 2015, IEX applied for exchange status (Investors Exchange [IEX]).

IEX differs from the other trading venues as IEX has created a speed bump to make the trading equal and fair to all investors. The speed bump creates a delay of three hundred and fifty millionths of a second (Tepper, 2016). According to IEX, the speed bump will not affect long-term investors, but it will have a large impact on traders that compete on speed, like high frequency traders.

A Business Insider article written by Turner (2015) relays that IEX is not the only exchange with this technique (altering the speed of traders' market access), but they are the only ones who use it fairly. The other trading venues alter speed only for those who

pay for the advantage. According to Pandey and Wu (2015), “IEX is able to route orders to multiple exchanges simultaneously in order to avoid front-running in a fragmented market” (p. 56). Since part of the larger problem with high frequency trader lies with front-running, IEX can help overcome that problem with the help of their speed bump.

IEX affects the market both positively and negatively, depending on the source. According to the SEC filing application website, many large investors and investment banks supports the idea of IEX being approved as an exchange. One of the people that is in favor of IEX becoming an exchange is Paul M. Russo, managing Director of the Securities Division for Goldman and Sachs. According to Russo, IEX will help to enhance the quality of U.S. equity markets. Russo believes that IEX will offer an exchange where traders who do not value the fastest speed and investors who want to trade larger blocks of stock will gain. Also according to the SEC filing application website, Charles M. Jones, Professor of Finance and Economics at Columbia Business School, wrote a response letter to the SEC not supporting IEX’s application for exchange status. Jones claims, “The Commission should think twice before approving a national securities exchange application with these anti-competitive features”. Jones states that the IEX speed bump is applied in a discriminatory way since the undisplayed orders at the IEX exchange will have an advantage over displayed orders at other exchanges. The IEX speed bump would be applied only 15% of the time. Jones analyzed data flow and found that, through the speed bump, investors with the disadvantage would be impacted by 1.67 cents per share.

CHAPTER VII: POTENTIAL REGULATIONS

The debate about the harm or aid to market quality brought about by high frequency trading continues. It is hard to determine a solution or even if a solution is needed. Harris (2013) suggests that the government enact a regulation requiring companies to announce to the exchanges when they expect important information to be revealed during trading hours. Harris also suggested that information should only be released when the market is closed or at a pre-announced time. Announcing information only at certain times, liquidity suppliers would have time to assess the impact of the information and thus not hurt the liquidity of the market. The law suggested by Harris is an action that many governments have already put in place. Harris's third and perhaps most helpful suggestion is that the best way to prevent high frequency traders from taking over the market would be to use a randomizer. If the regulators would delay each order between 0 to 10 milliseconds, high frequency traders would only "win" 59.5% of the time. A randomizer would diminish the problem of front running. It would also lower the cost of entry and reduce technology expenditures, which would not hurt or affect the quality of the market. The benefits would also ensure that high frequency trading is a competitive business where high frequency traders compete only with each other, and not institutional investors. By having high frequency trading companies compete with each

other and not ordinary investors, high frequency traders would continue to improve prices and quoted depth and would also provide the market with low transaction costs (Harris).

The problem that high frequency traders use algorithms to detect when a larger order is split and re-routed is hard to counteract without hurting the markets. For example, regulatory agencies cannot do much without "delaying or reducing the dissemination of quotes" (Harris, 2013, p. 7). They best way to solve the bigger problem, which is the existence of hunter/seeker algorithms, is to reduce the information about order sizes so that algorithms cannot detect them. Markets could report approximate order sizes instead of giving the actual order depth. The regulatory agencies can report approximate trade sizes through various buckets, or report on aggregated volumes at different intervals; incomplete order information together with hidden orders and dark pools would substantially reduce the ability for high frequency traders to identify future orders or trades (Harris).

More regulations have been implemented in Europe to regulate high frequency trading than have been implemented in America. European countries have different laws on how to regulate high frequency trading. So, the EU has standardized the rules that deal with high frequency trading through MiFID II. One main difference is that the European markets have formally stated what high frequency trading is, whereas the regulatory agencies in America have not. Gregoriou (2015) notes that banning high frequency trading is not going to solve the problem or help the markets. Pandey and Wu (2015) claim that high frequency traders, acting like market makers, should be required to have market maker obligations. If high frequency traders were obligated under law to help

stabilizing as was the case with market makers, it would take away one of the bigger concerns with high frequency trading.

CHAPTER VIII: INVESTOR CONFIDENCE AND ECONOMIC EFFECT

If institutional investors do not believe that markets are fair or safe, they will not invest in them. And if the institutional investors withdraw from the market, the U.S. economy, and potentially the world economy, will suffer. Björn Hagströmer, an Associate Professor of Finance at Stockholm University has said that the largest problem with high frequency trading is the lack of trust in the markets (Finansliv, 2015). The concern of investors is evidenced by the decrease of $232 billion in domestic equity mutual funds between May 2010 and January 2012 (Arnuk & Saluzzi, 2012).

A. GAINS AND LOSES ON HIGH FREQUENCY TRADING

Since high frequency traders took over market making roles, they became ultimately important for the future success of the exchanges. Since someone has to pay for others to receive, the short end of the stick happened to be drawn by large mutual funds that invest private working class Americans savings (Patterson, 2012).

Needless to say, the internet did not exist when the New York stock exchange started in 1792. At that time, the most convenient way to trade was to have a common place to go to trade. The New York Stock Exchange and Wall Street became that place. Specialists worked as market makers on the NYSE and were compensated by the spread between the buy and ask price. As explained earlier in this thesis, high frequency traders have taken over the market making role. Patterson (2012) explains the unfairness with a

market maker acting as a middle man, taking part of the average investor's profits. In today's society, we are no longer in need of the traditional way of trading in a common place, like the New York stock exchange. Today, many purchases are done through computers. Market makers may no longer need to match up orders, a computer could do it and save the investor money. All that is needed, according to Patterson, is to take out the market maker from the equation, and perhaps, the spread would not exist.

CONCLUSION

High frequency trading is a form of algorithmic trading using advanced algorithms and rapid speed to receive information and execute trades through co-located servers. Even though Arnuk and Saluzzi (2014) note that high frequency trading has declined, most likely due to increased competition, high frequency traders still had 50% of the market in 2012. High frequency trading has impacted the American and European markets tremendously and it paving the way for how future trading within the markets will be done.

Because of the rules implemented by the SEC, such as Reg ATS and Reg NMS, high frequency trading has grown and flourished. Through the "transparency" implemented by Reg ATS, high frequency traders could detect orders that were previously hidden in the markets. Changing from a $1/8 minimum tick size to a 100-point decimal system, together with the implementation of Reg NMS, made it cheaper and easier for high frequency traders to front run other traders. Through Reg NMS, orders had to be routed to the exchange with the best price. So, a large order would most likely have to be routed to multiple trading venues, which would lead to high frequency traders having more opportunities to front run the order. High frequency traders are able to purchase stock at a low price, and then sell if for a penny or so higher, making a profit. High frequency traders do this thousands of times per day, earning billions per year. All while eating away from hardworking Americans' retirement funds.

High frequency trading, in itself, is not harmful. However, proper regulations need to be implemented to deal with the complexity that high frequency trading brings with it. The European regulatory agencies have, through MiFID II, come a long way in dealing with high frequency trading. Moving forward into the 21st century, high frequency trading needs to be constantly monitored and regulations updated, to keep markets as efficient and fair as possible.

The average American will save for retirement using a 401K plan (or something similar). What most of these Americans don't realize is that part of their retirement savings is being eaten up by high frequency traders. The average individual will never know that money is missing from his/her savings, because high frequency traders will take only a little at a time. The small "tax" levied by high frequency traders is small when it is increasing the price paid by the retirement plan, however, it adds up to a substantial amount of lost investment at retirement time.

High frequency traders are not destroying the markets and it is not dangerous to invest your money in the market. High frequency traders will stay in the market and operate the same way they currently do if no new regulations are implemented. If no more regulations are implemented the glue that hold together our markets might crack. Technological advancement in the market should continue to grow and flourish, but it is important that they do so within the appropriate framework to support that growth.

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