

High Frequency Trading, the SEC, and the Legacy of the Flash Crash

by

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Abstract

High-frequency trading (HFT) is a significant evolution in financial markets which, combined with the Flash Crash of May 6th 2010, has been the impetus for many calls for regulation in the United States. This paper addresses the question regulation in two ways. First, is a review of the literature on the effects of high-frequency trading on the equities markets. The conclusion drawn from this review is that high-frequency trading generally improves quality (HFT passivity) but carries the potential to have negative effects during times of abnormal market behaviour (HFT aggression). This is used to inform an evaluation schema for the various regulatory proposals. Second, this schema is applied to various types of proposals for the regulation of high-frequency trading. The conclusion of this paper is that order-submission restrictions based upon price range are the best tool for promoting passivity among high-frequency traders while limiting the potential for aggressive behaviour.

Keywords: High-Frequency Trading; Flash Crash; Regulation; Security Exchange Commission; Order-Submission Restrictions

For Nicole Baker

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Glossary

| | |
|----------------------|--|
| Algorithmic Trading | A trading system that utilizes very advanced mathematical models for making transaction decisions in the financial markets. The strict rules built into the model attempt to determine the optimal time for an order to be placed that will cause the least amount of impact on a stock's price. |
| Circuit Breakers | After an index has fallen a certain percentage, the exchange might activate trading halts or restrictions on program trading. For example, if the Dow Jones Industrial Average falls by 10%, the NYSE might halt market trading for one hour. There are other circuit breakers for 20% and 30% falls. |
| Dark Liquidity Pools | The trading volume created by institutional orders that are unavailable to the public. The bulk of dark pool liquidity is represented by block trades facilitated away from the central exchanges. Also referred to as the "upstairs market," "dark liquidity" or "dark pool." |
| Erroneous Trade | A stock transaction that deviates so much from the current market price that it is considered wrong. Erroneous trades are caused by a variety of factors including computer malfunctions or human error. These trades are halted, or broken, because they do not reflect the true price of the security and they can influence or cause erroneous trades on other stocks or exchanges. |
| FINRA | Financial Industry Regulatory Authority: is a private corporation that acts as a self regulatory organization, a member of the regulation, enforcement and arbitration operations of the New York Stock Exchange |

| | |
|------------------------|--|
| High-Frequency Trading | HFT is defined as real-time computer-generated decision making in financial trading, without human interference and based on automatized order generation and order management. HFT encompasses short-term trading strategies, which – in extreme cases – operate in the range of microseconds using minimal price differences. |
| Liquidity | <p>(1) Buy-side and sell-side market depth, which is comprised of resting orders that market participants place to express their willingness to buy or sell at prices equal to, or outside of (either below or above), current market levels.</p> <p>(2) The degree to which an asset or security can be bought or sold in the market without affecting the asset's price. Liquidity is characterized by a high level of trading activity. Assets that can be easily bought or sold are known as liquid assets. . The ability to convert an asset to cash quickly. Also known as "marketability."</p> <p>(3) Liquidity means convertibility into money... [I]t connotes the price at which conversion can be made and is a price not out of line with what deemed appropriate for the commodity.</p> |
| Market Depth | The market's ability to sustain relatively large market orders without impacting the price of the security. This considers the overall level and breadth of open orders and usually refers to trading within an individual security. |
| Middleman | A party that will facilitate interaction between parties, typically for a commission or fee. |

| | |
|------------------------------------|--|
| National Best Bid and Offer – NBBO | A term applying to the SEC requirement that brokers must guarantee customers the best available ask price when they buy securities and the best available bid price when they sell securities. |
| Oder Flow Toxicity | A statistic used to monitor the stress to which market makers are subjected by informed traders, thus providing a high-frequency metric of the probability that the liquidity provision process may fail. |
| Order Imbalance | A situation resulting from an excess of buy or sell orders for a specific security on a trading exchange, making it impossible to match the buyers' and sellers' orders. For securities that are overseen by a market maker or specialist, shares may be brought in from a specified reserve to add liquidity, temporarily clearing out excess orders from the inventory so that the trading in the security can resume at an orderly level. Extreme cases of order imbalance may cause suspension of trading until the imbalance is resolved. |
| Quote Stuffing | A tactic of quickly entering and withdrawing large orders in an attempt to flood the market with quotes that competitors have to process, thus causing them to lose their competitive edge in high-frequency trading. This tactic is made possible by high-frequency trading programs that can execute market actions with incredible speed. Only market makers and other large players in the market are capable of executing these tactics, since they require a direct link to the exchange in order to be effective. |

Stub Quote

An order placed well off a stock's market price. Stub quotes are used by trading firms when the firm does not want to trade at certain prices and wants to pull away to ensure no trades occur. In order to make this happen, the firm will offer quotes that are out of bounds. A stub quote also serves as a safety net in that if a market maker doesn't have enough liquidity available to trade a stock near its recent price range, then a stub quote is entered so that the market maker complies with its requirements without extending its quotes beyond its available liquidity.

A stub quote is also referred to as a "placeholder" quote because this absurdly priced transaction would never be reached.

Volatility

A statistical measure of the dispersion of returns for a given security or market index. Volatility can either be measured by using the standard deviation or variance between returns from that same security or market index. Commonly, the higher the volatility, the riskier the security.

1. Introduction

On May 6th, 2010, the Dow Jones Industrial Average experienced its largest one-day point decline, 998.5 points,¹ the components of the DJIA dropping from -4 percent off their opening levels to -36 percent.² This is distinguished from other market crashes such as October 1987 or May 1962 by the unreasonable prices securities were being traded at; major “blue chip” stocks such as Accenture and 3M traded for pennies at various points³, and some 320 stocks lost over half of their market value.⁴ The market experienced excessive volatility and an evaporation of liquidity, only to be followed by a rally of 600 points some twenty minutes later, an event that quickly became known as the Flash-Crash. Following an investigation, the U.S. Commodity Futures Trading Commission and the U.S. Securities & Exchange Commission identified several key causes, namely *electronic transaction funds* and *high-frequency traders*⁵. The report was part of a broader effort by the United States Government to reform securities and exchange regulations.⁶

¹ David Easley, Marcos Lopez de Prado, and Maureen O'Hara, “The Microstructure of the ‘Flash Crash’: Flow Toxicity, Liquidity Crashes and the Probability of Informed Trading” *The Journal of Portfolio Management*, Vol. 37, No. 2, pp. 118-128, (Winter 2011). Available at SSRN: <http://ssrn.com/abstract=1695041> , 2-3.

² Andrei Kirilenko, Albert S. Kyle, Mehrdad Samadi and Tugkan Tuzun, “The Flash Crash: The Impact of High Frequency Trading on an Electronic Market”. (May 26, 2011). Available at SSRN: <http://ssrn.com/abstract=1686004>, 8.

³ Ananth Madhavan, “Exchange-Traded Funds, Market Structure, and the Flash Crash”, from: *Financial Analysts Journal* (Vol. 68, No. 4, July/August, 2012), 20.

⁴ Edgar Ortega Barrales, “Lessons from the Flash Crash for the Regulation of High-Frequency Traders”, from: *Fordham Journal of Corporate and Financial Law* (Vol. 17, Winter 2012), 1233.

⁵ U.S. Commodity Futures Trading Commission and Security Exchange Commission, *Findings Regarding the Market Events of May 6 2010: Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues*, September 30, 2010, 45.

⁶ 111th Congress of the United States of America, H.R. 4173 “Dodd-Frank Wall Street Reform and Consumer Protection Act”. (H.R. 4173) <http://www.sec.gov/about/laws/wallstreetreform-cpa.pdf>

High-frequency trading represents a relatively new phenomenon and has begun to play a significant role in the market, accounting for an average of nearly half of all equity trades per day in the United States.⁷ Hedge funds and specialized statistical arbitrageurs utilize sophisticated computer technology to identify and execute profitable trading opportunities, with little or no human involvement. High-frequency trades (HFTs) are typically characterized by a large orders designed to exploit short-term market inefficiencies. These trades typically have a holding period of seconds to minutes, only a fraction of what is normal for a trader who is a value-investor. Naturally, as with any technological revolution⁸ there is some recalcitrance and scepticism coming from established members of the investment and trading community.⁹ The events of the Flash-Crash could have only contributed to the scepticism of the benefits of this new type of trading techniques.

The rise of high-frequency trading and the question of what, if anything should be done about it poses an interesting problem for the study of regulation; namely how does regulation occur in relation to novel (an not necessarily fully understood) phenomena? At the broadest level it is the state that is responsible for determining the regulation of financial markets.¹⁰ The government, however, is not the lone stakeholder; the broader community of business actors (banks, financiers, investors etc.)¹¹ play a key role in influencing and shaping regulation (often through efforts such as wielding influence and lobbying).¹² At the broadest level, the general public is also a key factor in questions of regulation, usually bringing significant pressure to bear on the other two groups (in the

⁷ Frank Zhang, "High-Frequency Trading, Stock Volatility, and Price Discovery", (December 2010). Available at SSRN: <http://ssrn.com/abstract=1691679> , 1.

⁸ For an overview of high-frequency trading and how it has affected the markets see: Paul Zubulake and Sang Lee, *The High Frequency: How Automated Trading Strategies Have Revolutionized the Markets*, (Aite Group, John Wiley & Sons, 2011, Hoboken, New Jersey).

⁹ Robert A. Schwartz, John Aidan Byrne and Antoinette Colaninno eds., *Electronic vs. Floor Based Trading*, (Zicklin School of Business Financial Markets, Conference Series Barush College, City University of New York, Springer Science+Business Media Inc. 2006); Ivy Schmerken, "High-Frequency Trading Hits the Floor", from: *Wall Street & Technology*, (June 1, 2010).

¹⁰ John Braithwaite and Peter Drahos, *Global Business Regulation*, (Cambridge University Press, Cambridge, 2000), 112-113.

¹¹ *Ibid.*, 158-159.

¹² *Ibid.*, 120-121.

form of direct political pressure in elections, or indirectly through the establishment of NGOs that can exert pressure i.e., consumer advocacy), especially in times of financial or economic upheaval.¹³

These groups, with numerous levels of interaction between them form an epistemic community¹⁴, the purpose of which is to “(e)nroll the support of strategic actors for the regulatory change.”¹⁵ In terms of the regulatory system for matters of the economy and finance within the United States¹⁶, the epistemic community is highly important to steering the direction of regulation (changes to the regulatory structure do not simply stem from government fiat).¹⁷ The community, in this case, has a name to which nearly everyone is familiar with: *Wall Street*.¹⁸ At the conjunction of the various components of this community on the matter of financial markets are regulatory bodies such as the *Security Exchange Commission*, *Commodity Futures Trading Commission* and the *Financial Industry Regulatory Authority*. While it ultimately the Congress of the United States Government that sets laws regarding financial markets, it is up to such executive agencies to implement the law.¹⁹

Traditionally, innovations in financial matters (such as high-frequency trading) have hit Wall Street first, forcing bodies such as the SEC to deal with them (something the SEC has a fairly successful track record of doing).²⁰ Indeed on the matter of the

¹³ Ibid., 122-123.

¹⁴ “Large audiences of state, business and NGO actors who meet sporadically and share a common regulatory discourse based on shared knowledge, sometimes technical requiring professional training” – ibid., 24.

¹⁵ Ibid., 29.

¹⁶ High-Frequency trading is not just a phenomena restricted to the U.S. markets (though the U.S. is the focus of this paper). Regulators of European exchanges have had to also address this issue, see: Latteman, Christoph et. al., “High Frequency Trading: Costs and Benefits in Securities Trading and its Necessity of Regulations”, From: *Business & Information Systems Engineering*, (Vol. 4, No. 2, April 2012).

¹⁷ Braithwaite and Drahos 123.

¹⁸ Ibid., 161, 174.

¹⁹ Kathryn C. Lavelle, *Money and Banks in the American Political System*, (Cambridge University Press, Cambridge, 2013), 124.

²⁰ Braithwaite and Drahos, 157.

Flash-Crash and HFTs, Congress has placed the issue in the hands of the SEC²¹ through the financial reforms set out in the Dodd-Frank act.²² In the most general sense, the impetus for Congress pushing the SEC to deal with high-frequency trading stems from public pressure for reform after the 2008 Financial Crisis and the presidential election. The Senate seat vacated by Joe Biden's move to the executive branch was eventually filled by Ted Kauffman, a former businessman and political advisor. Kauffman, only filling out the remaining two years of Biden's full term, began to pressure Congress and regulators on a number of issues regarding economic and financial policy²³, one of which was to deal with the emergence of high-frequency trading.²⁴

The state of affairs for regulation of HFTs in the period between the 2008 election and the Flash-Crash in 2010 was not one that favoured the emergence of a new regulatory framework. The traditional understanding of markets and questions of regulation by members of Congress and those working in the relative executive agencies was outdated.²⁵ Wherein there was this lack of understanding of emerging market issues, a confluence of two factors prevented Congress from adequately addressing any potential problems of HFTs. First, most members of Congress appeared "daft" or rather unable /unwilling to understand the implications of the evolution of high-frequency trading.²⁶ Secondly, the general lobbying of those in the financial industry almost always

²¹ While there are other bodies governing the exchanges, the matter has fallen on the SEC rather than others. The Financial Industry Regulatory Authority who's stated goal is to protect investor protection and market integrity "through effective and efficient regulation of the securities industry" (Financial Industry Regulatory Authority Website, About FINRA, <http://www.finra.org/AboutFINRA/> (Accessed December 15, 2013), has been subject to significant amounts of criticism in wake of the 2008 Financial Crisis [Jeff Connaughton, *The Payoff: Why Wall Street Always Wins* (Prospecta Press, Westport, Connecticut, 2013), 173]. For a discussion of the role of the SEC vs. that of the CFTC, see the beginning of Section 4 of this paper.

²² H.R. 4173

²³ Connaughton, 9.

²⁴ Ibid., 159.

²⁵ "Our stock market had changed dramatically. No one understood how these changes were affecting average investors. Today's stock market is a constantly evolving bewilderingly complex electronic labyrinth. Not even sophisticated traders can say with certainty what happens to their order when they buy or sell shares of a stock." – Ibid., 161.

²⁶ Ibid., 167.

portrayed the evolution as a positive, and that the status quo²⁷ was beneficial for everyone.²⁸ When pressured for input on possible regulatory changes, these banks and hedge funds were completely reluctant to engage with legislators and regulators.²⁹

Despite these problems, the question of HFTs began to receive significant attention. Their growth within the markets and subsequent enormous profits (some \$8 Billion in 2009)³⁰ began to garner increasing attention of the press and a wider audience.³¹ Yet this attention resulted only in a review of the emerging market issues in terms of fairness, not market quality.³² Though many may have perceived that the rise of HFTs may generate something akin to a market crash, this point was not the central focus of the discussion of high-frequency trading in the period 2008-2010. As noted above, the broader public, often panicked after significant upheaval in the economy, forms a significant body that brings pressure for regulatory change. Indeed, Congress often waits for a disaster before stepping in to address the situation.³³ Though Senator

²⁷ Besides a common-sense skepticism of the efforts of lobbyists; this issue of the status quo within markets, where there is no regulation of high-frequency trading, poses some issues. Simply, not all within the financial community benefit equally from HFTs. Perhaps the sharpest divide is between manual traders (individual day-traders) and algorithmic or high-frequency traders, where the latter has a significant competitive advantage over the former. Algorithmic traders experience execution costs for trades that are 1/6th of that for manual traders [Edward Leshik and Jane Cralle *An Introduction to Algorithmic Trading: Basic to Advanced Strategies* (John Wiley & Sons, 2011), 4.] A second consideration is between the difference between those banks and hedge funds who are high-frequency traders and those market actors who are institutional investors. The former are often proprietary trading firms, which trade exclusively on their own capital (Barrales, 1218-1219). These firms utilize HFTs as a method for generating profit. Institutional investors are large, non-bank entities (often pension funds or life-insurance companies) who invest on behalf of a client base. [Investopedia, Definition of Institutional Investor, <http://www.investopedia.com/terms/i/institutionalinvestor.asp> (Accessed December 15, 2013)]. The lobbyists articulating the benefits of the status quo might not (and probably did not) address concerns of institutional investors.

²⁸ Connaughton, 162.

²⁹ Ibid., 170.

³⁰ Ibid., 164.

³¹ Ibid., 162.

³² The primary difference here is that fairness is a question of relative advantages, i.e., questions of high-frequency trading benefiting certain portions of the trading public. Market quality is an issue of stability and viability of the market as a whole. This issue is further discussed in Section. 4. of this paper.

³³ Connaughton, 175

Kauffman³⁴ was attempting to demonstrate that Congress could conduct effective real-time regulation of emerging issues, little progress was made.³⁵ The political tug-of-war over Dodd-Frank and dealing with the 2008 crisis between the two parties made the sort of regulatory project put forward by Kauffman too difficult to achieve.³⁶ The Flash-Crash of May 6th, 2010, provided just the crisis needed to jump-start a process regulatory change. In terms of the Dodd-Frank financial reforms (passed only a few months after the Flash-Crash), the SEC was directed by Congress to address the emergence of high-frequency trading. The combination of the lack-luster performance of regulators in relation to the 2008 disaster and practices of Bernie Madoff, resulted not only in political, but also significant public pressure on SEC to improve its performance in regulating the markets.³⁷ The Flash-Crash proved to be a stimulus to the financial community itself, a 2010 poll of market participants on the New York Stock Exchange believing that high-frequency trading to be the biggest structural issue facing the market place³⁸, indicating that this portion of the Wall Street community acknowledged that the status quo might require revision.

The events of the Flash-Crash should bring the epistemic community towards bringing about a change in regulation. Public pressure moved the government to consider regulation, with Congress responding with a nod to HFTs in Dodd-Frank. The financial community also demonstrated an awareness of the evolution of high-frequency trading and potential structural issues that may need to be addressed (thereby lessening resistance among this portion of the community). Yet, one final issue remains for any regulation of high-frequency trading: general un-enlightenment. Where dialogue and discourse between the members of the community is the method by which cooperation

³⁴ Throughout Connaughton's narrative of Senator Kauffman's two year term, the author makes numerous notes of the Senator as the lone politician pushing for changes on the matter of high-frequency trading (pg. 178). It is important to note that the author does not claim that that the Senator had any special insights into high-frequency trading but rather his experiences in the business community made him more aware of the emergence of HFTs as a phenomena requiring the attention of regulators.

³⁵ Ibid., 175

³⁶ Ibid., 221-223.

³⁷ Ibid., 169.

³⁸ NYSE Euronext, STA Poling Center, N8891/101029, (2010), <http://www.nyse.com/pdfs/STA%20Poll%20Responses.pdf> (Accessed December 15, 2013).

on regulatory issues comes about³⁹, it is difficult to understand how such dialogue can occur when many of the actors involved do not necessarily know what they are talking about. Simply put, the novelty of high-frequency trading means that little empirical understanding exists.

Nevertheless, the SEC is moving forward with proposing possible regulatory options (in compliance with Dodd-Frank). The purpose of this research project will be to examine the effects of high-frequency trading on the markets as well as the regulatory changes being considered. This research agenda should help to inform primarily the SEC's decision-making process on regulation but also the general discussion of the effects of high-frequency trading on the markets.

As will be seen below, it would seem that high-frequency trading has a net positive effect on the quality of the market, providing increased liquidity and efficiency. However, the Flash-Crash exposed a serious problem, the namely ability of high-frequency trades to exacerbate negative market trends in times of heightened volatility. Simply put, all things being equal, high-frequency trading is beneficial to the market; but during periods where there is increased chances of drastic market movements, high-frequency trading can exacerbate negative market behaviour. Given this, a number of changes have been implemented to the regulatory system governing U.S. Exchanges intended to prevent or the limit the effect of another Flash-Crash –like event, with proposals for further regulatory practices having been put forward to U.S. Securities Exchange Commission. These proposals come in four main types: (1) heightened responsibilities for high-frequency traders, (2) incentives for HFTs to provide liquidity to the market (3) limits on the submission of high-frequency trade orders and (4) a Financial Transaction Tax.

Ostensibly heightened responsibilities in the form of registering as market makers, would legally force high-frequency traders to avoid acting in a way that exacerbates negative market movements. Changes in incentives such as a rebate fee system and lower transaction fees for trades that would not contribute to a negative market trend should make high-frequency traders less likely to engage in more predatory

³⁹ Braithwaite and Drahos, 32.

practices by encouraging marginal trades. Limits on the submission of high volume orders would be intended to limit the access high-frequency traders have to the market, thereby limiting their potential negative effects. A financial transaction tax would limit the profitability of trading on small margins, dramatically lowering the number of profitable trading opportunities for HFTs, essentially “slowing down” the market.

Table 1. Categories of HFT Regulatory Proposals

| Regulation | Mechanism | Intended Effect |
|--|---|--|
| 1. Market Maker Responsibilities | Legal obligation to provide liquidity in times of stress, and to avoid trading in a manner that would exacerbate price movement in a negative fashion. ⁴⁰ | Legal restrictions on HFT behavior thereby limiting the likelihood of HF trades exacerbating negative market moves. |
| 2. Incentives for HFTs and Market Making | Providing incentives for HFTs to behave as market makers through higher rebates for liquidity provision. ⁴¹ | Encouraging HFT participation as market makers as a well engaging in general behavior that is advantageous to the market as a whole. |
| 3. Order Submission Restriction | A. A minimum period that orders must be posted. ⁴² B. Limits on the number of orders that can be posted in a given period. ⁴³ C. Limits on the submission of orders based upon price range. ⁴⁴ | A. A minimum post period would essentially “slow down” the speed of HFTs. B. Limiting the negative HFT influences by restricting the rate at which they may submit orders and quote to the market, improving informational efficiency. C. Limiting price movements by flagging or cancelling trade offers at levels significantly different from that of the current market price. |

⁴⁰ Barrales, 1246-1247.

⁴¹ Ibid. 1248-1249.

⁴² Ibid. 1249-1251.

⁴³ Carol Clark, “How to Keep Markets Safe in the Era of High-Speed Trading”, Chicago Fed Letter (Vol. 3003, October 1, 2012), Nathan D. Brown, , “The Rise of High Frequency Trading: The Role of Algorithms and the Lack of Regulations, Play in Today’s Stock Market”, From: *Appalachian Journal of Law*, (Vol. 11, No. 2, January 2012), 226.

⁴⁴ Alyse L. Gould, “Regulating High-frequency Trading: Man v. Machine”, From: *The Journal of High Technology Law*, (Vol. 12, January 2012), 316-317.

| Regulation | Mechanism | Intended Effect |
|------------------------------|--|---|
| 4. Financial Transaction Tax | A fee of 3 basis points assessed on every \$100 in volume in a given transaction on the exchanges. ⁴⁵ | Generally, the tax is intended to provide added revenue, but in the case of high-frequency trading, it would decrease trading volume by limiting the profitability of trading on small margins. ⁴⁶ |

The literature reviewed in this paper will show that high-frequency trading is generally beneficial to the markets, but can become highly detrimental as during the Flash Crash. The behaviour of HFTs will thus be categorized as either passive (HFTs acting a way that promotes positive market quality, specifically liquidity provision⁴⁷) and aggressive, meaning liquidity consuming. This categorization of passive vs. aggressive HFT behaviour will be combined with a general statement of intent from the SEC, "... (to) protect investors, maintain fair, orderly and efficient markets and facilitate capital formation"⁴⁸ to form a general schema for evaluating these proposals: Any efforts taken by the SEC in relation to regulating high-frequency trading should be done with the objective of limiting or preventing aggressive (liquidity consuming) behaviour without harming or impeding the ability for HFTs to function in a passive (liquidity providing) manner. This will be done not only using background information on HFT behaviour identified in the literature review, but also tested against the narrative of what happened during the Flash Crash, evaluating their likely effects if another such event were to

⁴⁵ Office of Senator Tom Harkin, Press Release: "Harkin, DeFazio Welcome EU Action on Transaction Tax; Announce Plans to Reintroduce US Bill". (January 22, 2013), From: <http://www.harkin.senate.gov/press/release.cfm?i=339332> (Accessed October 1, 2013).

⁴⁶ Mark Rosenman: "A New Tax to Raise Money for the US and Slow High-Frequency Trading.", (September 13, 2013), from: <http://www.pbs.org/newshour/businessdesk/2013/09/a-new-tax-to-raise-money-for-t.html>, (Accessed October 1, 2013).

⁴⁷ The degree to which an asset or security can be bought or sold in the market without affecting the asset's price. Liquidity is characterized by a high level of trading activity. Assets that can be easily bought or sold are known as liquid assets. . The ability to convert an asset to cash quickly. Also known as "marketability." From: Investopedia: Broker Terminology: "Liquidity Definition", from: <http://www.investopedia.com/terms/l/liquidity.asp> (Accessed March 12th, 2013).

⁴⁸ Securities and Exchange Commission "The Investor's Advocate: How the SEC Protects Investors, Maintains Market Integrity and Facilitates Capital Formation", <http://www.sec.gov/about/whatwedo.shtml>, (Accessed May 9th, 2013).

occur. Given both the literature on HFTs and the Flash Crash, the proposal to restrict order submissions based upon price range (3.C in the table above) best satisfies this schema.

The structure of the paper will be as follows: Section 2 will contain some key background material on high-frequency trading, the Flash-Crash, and a discussion of role of regulators and the proposals noted above. Section 3 will consist of a literature review of the works on the effects of high-frequency trades on market quality, specifically in terms of liquidity and volatility, making note of both passive (positive, liquidity providing) and aggressive (liquidity consuming) HFT behaviour. Section 4 will discuss the role of, and problems facing, regulators as well as the notion of market-failure versus government failure. This section will then articulate the schema for evaluating the proposals for HFT behaviour (based upon the literature review) which will then be applied to the proposals for improved regulatory practices for high-frequency trading: (1) heightened market maker responsibilities, (2) liquidity provision incentives through rebate fees, (3) order submission restrictions, (4) a Financial Transaction Tax. This paper will show that an order restriction submission, based upon restrictions on price range would best satisfy the schema used and should be the regulatory direction taken by SEC in order to minimize the chance of government failure. Section 5 will contain a review of the arguments of this paper, the conclusion, and proposals for further research.

2. Background Information

The following section contains background information and key elements to be used in the analysis in this paper. Section 2.1 provides a general description of high-frequency trading as a market phenomena. Section 2.2 gives a brief summary of the events of the Flash Crash and the role HFTs played in it. 2.3 Discusses the role of SEC and regulations.

2.1 High-Frequency and Algorithmic Trading

One of initial challenges of this topic is the definition of high-frequency trades. Algorithmic trading (AT) is the process by which trading strategies are processed or executed. These are computer algorithms programmed to execute a series of trades matched to a general trading formula and mathematical models, triggered by sensors monitoring market performance: quotes, trades, order-books and indicators of interest.⁴⁹ As these algorithms were designed to mimic established execution strategies of traditional traders through statistical arbitrage, AT usually refers to the systematic execution process of buy- and sell- decisions.⁵⁰ Algorithmic trading, then, is merely the computer execution of predetermined trading strategies based upon realized opportunities. The process of electronification of securities trading began in the 1970s with the creation of National Association of Securities Dealers (NASD), and when taken into conjunction with a system of automated quotation, formed the NASDAQ.⁵¹ Where the majority of volume in stock trading had once been executed in a manual fashion,

⁴⁹ David. J. Leinweber, *Nerds on Wall Street: Math, Machines and Wired Markets*, (John Wiley & Sons, Inc., 2009, Hoboken, New Jersey), 72.

⁵⁰ Irene Aldridge, *High-Frequency Trading: A Guide to Algorithmic Strategies and Trading Systems*, John Wiley & Sons (2010, Hoboken, New Jersey), 15.

⁵¹ Gomber et. al. "High-Frequency Trading". (2011). Available at SSRN: <http://ssrn.com/abstract=185862> , (Accessed January 13, 2013), 8.

traders at desks or on the exchange floor, automated execution is now the norm.⁵² Algorithmic trading began to establish its foothold in the market in the early 1980s by being able to exploit profitable opportunities in a more expedient manner than the “old school” traders.⁵³

High-frequency trading firms have the potential to generate an astounding number of trades, sometimes exceeding over one million per day, representing a plurality, if not outright majority of volume on a given day.⁵⁴ The main distinguishing characteristics of high-frequency trades (HFTs) from other ATs are their relatively short holding times, rapid execution, and full automation⁵⁵: “... HFT is defined as real-time computer-generated decision making in financial trading, without human interference and based on automatized order generation and order management. HFT encompasses short-term trading strategies, which – in extreme cases – operate in the range of microseconds using minimal price differences.”⁵⁶ High-frequency trading is simply ATs with minimal execution and holding times. Irene Aldridge provides us with this Categorization of HFTs:

⁵² Mary L. Schapiro, “Strengthening Our Market Equity Structure”, (Speech by the SEC Chairman, U.S. Securities and Exchange Commission, The Economic Club of New York, September 7th 2010), <http://www.sec.gov/news/speech/2010/spch090710mls.htm> (Accessed September 3rd. 2013)

⁵³ Leinweber, pg. 67-68.

⁵⁴ Schapiro

⁵⁵ Leinweber. 18.

⁵⁶ Latteman, Christoph et. al., 93.

Table 2. Overview of High-Frequency Trading Strategies

| HFT Strategy | Description | Typical Holding Period |
|-------------------------------|---|------------------------|
| Automated Liquidity Provision | Quantitative algorithms for optimal pricing and execution of market making positions. | < 1 Minute |
| Market Microstructure Trading | Identifying trading party overflow through reverse engineering of observed quotes. | < 10 Minutes |
| Event Trading | Short-term trading on macro events. | < 1 Hour |
| Deviations Arbitrage | Statistical arbitrage of deviations from equilibrium: triangle trades, basis trades and the like. | < 1 Day |

From: *High-Frequency Trading: A Guide to Algorithmic Strategies and Trading Systems*.⁵⁷ For a more comprehensive examination of the various definitions of algorithmic and high-frequency trading, see Gomber et. al., “High-Frequency Trading”.⁵⁸ Not all algorithmic trades are high-frequency, HFTs are ATs with low execution latency and low position holding period.⁵⁹ For the remainder of this paper, ‘HFT’ and ‘AT’ will be used interchangeably in order to fit the terms as used by the authors being reviewed. When algorithmic trades are mentioned, they refer to the category of trades that can also be described as high-frequency.

High-frequency trading firms are looking to compete with other investment actors for quick access to market inefficiencies⁶⁰: “High-frequency trading aims to indentify and arbitrage temporary market inefficiencies that are created by competing market participants.”⁶¹ Such opportunities are often short-lived, computers are able to scan the market for them and execute appropriate trading strategies;⁶² HFTs then, are not entirely new, but rather are a product of the evolution of the securities markets.⁶³ Historically, markets have always had significant processing costs, mostly associated with searching the available positions looking for profitable trading opportunities. HFTs

⁵⁷ Aldridge, 4.

⁵⁸ Gomber et. al., 74-77.

⁵⁹ Aldridge, 17.

⁶⁰ Aldridge, 24.

⁶¹ Ibid. 61.

⁶² Gomber et. al., 27.

⁶³ Latteman, Christoph et. al., 100.

make this process less expensive: “Participation externalities are severely reduced when markets change from humans on floors to machines on electronic markets where search costs are significantly reduced.”⁶⁴ To put it more simply, HFTs make it less expensive for investors to gain access to the market and find profitable trading opportunities.

The largest challenge for researchers into the nature, function, and effects of high-frequency trades is the lack of empirical information.⁶⁵ Indeed most of the contemporary evidence of the effects of HFTs comes from news and anecdotal stories.⁶⁶ High-frequency traders themselves are reluctant to make their data public due to the competitive nature of the market, any publicly revealed information on HFT strategies would render them unprofitable as the market as a whole would rush to trade upon them.⁶⁷ An investment firm using trading algorithm of which the specific strategy is public knowledge would be exposed to manipulation and exploitation. The programming or source code for individual algorithms are now considered proprietary technology and guarded accordingly.⁶⁸ Thus limited public data exists from which to conduct a thorough analysis of the functioning and effects of high-frequency trading. A 2009 survey of institutional investors found that 85 percent of respondents felt they lacked adequate data to make any “final judgments” on HFTs.⁶⁹ As will be seen below, high-frequency trading has generally positive effects (Section 3.1), but the role that they played during the Flash-Crash leads to some healthy skepticism (Section 3.2 and 3.3).

⁶⁴ Albert J. Menkveld, “High Frequency Trading and the New-Market Makers”, (February 12, 2013). EFA 2011 Paper; AFA 2012 Paper. Available at SSRN: <http://ssrn.com/abstract=1722924> , (Accessed February 19, 2013), 6.

⁶⁵ Chaboud et. al., “Rise of the Machines: Algorithmic Trading in the Foreign Market”, Board of Governors of the Federal Reserve System, International Finance Discussion Papers, Number 980, (October 2009), 1.

⁶⁶ Jonathan A. Brogaard, “High Frequency Trading and Its Impact on Market Quality”, from: www.futuresindustry.org/ptg/downloads/HFT_Trading.pdf (Accessed March 16th, 2013), 3.

⁶⁷ Irene Aldridge, *High Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems*, (John Wiley & Sons, 2010), 6.

⁶⁸ See *United States v. Aleynikov and The 112th Congress of the United States*, “Theft of Trade Secrets Clarification Act of 2012”, *Congressional Record*: <http://thomas.loc.gov/cgi-bin/query/z?r112:H18DE2-0051> , (Accessed September 23, 2013).

⁶⁹ Katherine Heires, “High Frequency Trading: New Study Finds Divide on Impact”, *Securities Technology Monitor*, <http://www.securitiestechologymonitor.com/news/-24116-1.html> (Accessed February 28, 2013).

2.2 High-frequency Trading and the Flash Crash⁷⁰

May 6th, 2010 was a rough day for equities and securities markets, unusually high volatility was seen as well as a general thinning of liquidity.⁷¹ At 2:32 p.m., a large fundamental trader (hedge fund) initiated a massive sale of approximately \$4.1 billion futures contracts⁷² which was initially absorbed by high-frequency traders as well as the broader market as a whole (mostly other fundamental traders).⁷³ Approximately 9 minutes later, HFTs began to aggressively posting sell orders in intending to limit their positions and exposure to the market⁷⁴ causing two significant problems. The first is best described as a general liquidity crisis: the buy-side depth⁷⁵ for futures fell to 1% of its size of that morning.⁷⁶ This lack of liquidity was exacerbated by the inability of HFTs to find interested long term parties⁷⁷, causing them to rapidly buy and re-sell contracts to one another, what the SEC called a “hot-potato” effect!⁷⁸ “Between 2:45:13 and 2:45:27, HFTs traded over 27,000 contracts, which accounted for about 49% of the total trading volume, while buying only about 200 additional contracts net.”⁷⁹ The role high-frequency trading played in this process was critical, the net volume on the sell-side exceeded 15 times the average of the same period over the previous three days.⁸⁰ The general

⁷⁰ This section constitutes a brief summary of the analysis Flash-Crash conducted by U.S. Regulators, U.S. Commodity Futures Trading Commission and Security Exchange Commission, *Findings Regarding the Market Events of May 6 2010: Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues*, September 30, 2010.

⁷¹ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 2, 9-10.

⁷² *Ibid.*

⁷³ *Ibid.*, 3.

⁷⁴ *Ibid.*

⁷⁵ “The market’s ability to sustain relatively large market orders without impacting the price of the security. This considers the overall level and breadth of open orders and usually refers to trading within an individual security.” From: Investopedia: “Market Depth”, <http://www.investopedia.com/terms/m/marketdepth.asp> (Accessed September 30, 2013).

⁷⁶ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 3-4, 24.

⁷⁷ *Ibid.*, 14-15.

⁷⁸ *Ibid.*, 3-4.

⁷⁹ *Ibid.*, 3.

⁸⁰ *Ibid.*, 5.

imbalance in orders⁸¹ rapidly pushed prices down as HFTs continually looked for a price at which longer-term or fundamental investors would be willing to enter into the buy side. Between 2:41 p.m. and 2:45 p.m. the value for futures contracts based upon stocks in the S&P 500 fell by 5%, indicating a general inability or unwillingness among the market as a whole to supply liquidity on the buy-side.⁸² This overall decline triggered risk limits set internally by most market makers (traders who post quotes on both the buy- and sell-side), causing them to widen their posted-bid ask spreads and lower the number of shares offered at those prices⁸³, furthering the liquidity crisis.

The crisis spread as some HFTs as well as various fundamental traders began to withdraw from the market⁸⁴ leading to a further decline in market liquidity. In reconstructing the events of May 6th, a number of firms interviewed by the SEC cited “data integrity” concerns in explaining why they chose to strongly limit their exposure to the market.⁸⁵ Simply put, many believed the price movements they observed could only be the result of computer errors and not the result of any trading actually occurring on the market. The practice among most firms under these circumstances is to implement a self-imposed trading halt in order to start checking the integrity of their computer systems, limiting the potential for losses from trades based on faulty data.⁸⁶

This larger withdrawal of firms caused the second major problem, a crisis in individual stocks and securities. As traders became increasingly incapable of finding counterparties across the broader markets, trades based upon “stub quotes” posted by

⁸¹ Ibid., 32-35.

⁸² Ibid., 15

⁸³ Ibid., 38.

⁸⁴ Ibid., 5

⁸⁵ Ibid., 36-37.

⁸⁶ Ibid. 4.

market makers were triggered⁸⁷ causing extreme volatility in prices where normally stable “blue-chip” stocks traded at completely irrational levels (as low as one penny and as high as \$100,000).⁸⁸ Some stability was returned to the market between 2:45 p.m. and 3:08 p.m. when the balance between the buy and sell sides became stabilized, re-floating prices.⁸⁹ A sharp increase in depth on the buy-side occurred just after trading in futures contracts on the Chicago Mercantile Exchange was suspended in order to prevent a further cascade of prices.⁹⁰ The majority of this was due to fundamental and large cross market trading firms entering the buy-side as the low prices provided profitable arbitrage opportunities.⁹¹

Overall, the SEC concluded that high-frequency traders played a significant role during the Flash-Crash. The activity of high-frequency traders rose significantly on May 6th eventually reaching a peak of around 250% during the period where the broader equities market began to experience the crash (2:43 p.m. through 2:46 p.m.),⁹² and were also found to be primarily net- sellers of stock and securities during the event.⁹³ In terms of behavior, HFTs generally became liquidity consumers in two key ways: (1) they exacerbated negative price movements by rapidly trading on the sell-side and/or (2)

⁸⁷ “[An] Order placed well off a stock's market price. Stub quotes are used by trading firms when the firm doesn't want to trade at certain prices and wants to pull away to ensure no trades occur. In order to make this happen, the firm will offer quotes that are out of bounds. A stub quote also serves as a safety net in that if a market maker doesn't have enough liquidity available to trade a stock near its recent price range, then a stub quote is entered so that the market maker complies with its requirements without extending its quotes beyond its available liquidity. A stub quote is also referred to as a "placeholder" quote because this absurdly priced transaction would never be reached.” From: Investopedia, “Stub Quote”, <http://www.investopedia.com/terms/s/stub-quote.asp> (Accessed March 10, 2013). See Appendix 1 for a examination of the Security Exchange Commissions' banning of these sort of trades.

⁸⁸ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 5.

⁸⁹ *Ibid.*, 16.

⁹⁰ *Ibid.*, 4.

⁹¹ *Ibid.*, 17-18.

⁹² *Ibid.*, 46.

⁹³ *Ibid.*, 47.

actively pulling out of or limiting exposure to the market.⁹⁴ While they were not the immediate cause of the crash, they certainly played a key role, leading many to argue that an improved regulatory framework is needed in order to deal with high-frequency trading.

2.3 Regulation and High-frequency Trading

The general role of the Securities and Exchange Commission is to “protect investors, maintain fair, orderly and efficient markets and facilitate capital formation.”⁹⁵ This gives the SEC two interrelated (but sometimes divergent) objectives, that of the soundness and stability of the system and that of an entity that focuses on “fair” rules of conduct.⁹⁶

The remainder of this paper will focus on the former, that of regulators working to ensure a level of stability in the markets.⁹⁷ This principle was echoed by the SEC Chairman in the aftermath of the Flash-Crash in a speech to the Economic Club of New York: “It falls to the SEC to ensure that the rules governing market structure and market participant behavior foster fair, reliable and resilient markets that warrant the full confidence of investors and listed companies.”⁹⁸ The issue of confidence in the market is not that difficult to understand, the potential for Flash-Crash-like events almost

⁹⁴ In their analysis of the Flash Crash, the CFTC and SEC “...did not find uniformity in response to market conditions on May 6. Although some HFTs exited the market for reasons similar to other market participants, such as the triggering of their internal risk parameters due to rapid price moves and subsequent data-integrity concerns, other HFTs continued to trade actively.” – Ibid. 45.

⁹⁵ Securities and Exchange Commission “The Investor’s Advocate: How the SEC Protects Investors, Maintains Market Integrity and Facilitates Capital Formation”.

⁹⁶ Chester S. Spatt, “Regulatory Conflict: Market Integrity vs. Financial Stability, from: *University of Pittsburgh Law Review* (Vol. 71. No. 3., Winter 2009), 625.

⁹⁷ It is possible to conceive of HFTs as acting in an “unfair” manner towards other market participants, specifically on the issues of co-location and speed, that the low-latency access required gives HFTs an advantage over other market participants. See Gomber et. al. 34-35; Brown, 221-224 and Justin Sandler, “The Invisible Power of Machines: Revisiting the Proposed Flash Order Ban in the Wake of the Flash Crash” *Duke Law & Technology Review* (2011, no. 3)

⁹⁸ Mary L. Schapiro, “Strengthening Our Market Equity Structure”, (Speech by the SEC Chairman, U.S. Securities and Exchange Commission, The Economic Club of New York, September 7th 2010)

certainly can deter investors from the market due to uncertainty and turmoil.⁹⁹ Regulators play a key role in shaping market structure, primarily towards the objectives of stability and fairness: “[I]f the equity market structure breaks down – if it fails to provide the necessary and expected fairness, stability and efficiency – investors and companies pull back, raising costs and reducing growth.”¹⁰⁰ Preventing market turmoil like that of May 6th 2010 is thus a primary focus of market regulators. The Chairman of the SEC commented on some of the more serious impacts, noting the potential for severe losses for the broader market, providing a conservative estimate of \$200 million in losses for those that sold during the worst of the turmoil that occurred between 2:30 and 3:00 p.m.¹⁰¹ This sort of occurrence violates one of the long held principles of U.S. Equities markets: “[Investors] can have confidence that they will be able to sell that stock at a fair and efficient price...”¹⁰²

The SEC began implementing regulatory changes in the wake of the Flash-Crash, namely, improved circuit breakers (to halt trading in cases of extreme price movements) banning stub-quotes (the device that triggered trades at abnormally high and low prices), improved rules for erroneous trades (trades submitted so far outside of the general price range that they are thought to be the result of errors) and improved audit system to aid regulators in monitoring the markets.¹⁰³ These changes certainly would have alleviated some of the problems of the Flash Crash, but they are generally considered woefully insufficient by many commentators.¹⁰⁴ This is even acknowledged by the SEC itself, “[W]e (the SEC) have not waited for the report to begin taking steps toward the weaknesses identified on May 6th”¹⁰⁵ The first moves for regulatory changes, specifically the market wide circuit breakers and audit trail system, were made on May

⁹⁹ Pamela J. Craig, Prepared Statement before the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues, August 11th, 2020, from: <http://www.sec.gov/comments/265-26/265-26-29.pdf> (Accessed September 2nd, 2013).

¹⁰⁰ Ibid.

¹⁰¹ Ibid.

¹⁰² Ibid.

¹⁰³ Gomber et. al., 45.

¹⁰⁴ See Appendix 1 for a discussion of these changes as well as an analysis of their shortcomings.

¹⁰⁵ Schapiro, “Strengthening Our Market Equity Structure”

10th 2010, only 4 days after the Flash Crash.¹⁰⁶ Broader changes are thus recognized as necessary to better ensure stable markets¹⁰⁷, a fact that led the U.S. Congress to direct the SEC to conduct research and propose legislation for the regulation of high-frequency trading.¹⁰⁸

As noted above, many financial experts believe that there is presently insufficient data in order to draw any final conclusions about high-frequency trading.¹⁰⁹ This presents a problem for regulators, namely how should they go about regulating something they do not have an adequate understanding of? Generally, those implementing policies are faced with three choices: the “positive” options that alters the status quo, “negative” options that preserve the status quo and “non-decisions” where deviation from the status-quo is not even considered.¹¹⁰ Given that the SEC has been ordered by Congress to propose regulation for high-frequency trading, the non-decision option must be discarded as the status quo entails virtually nothing that regulates high-frequency traders specifically.¹¹¹ It does not seem inappropriate to suggest that the SEC wait until more is known about the effects of high-frequency trading before making decisions regulating it, hopefully allowing for more refined and effective approach. However given the fact that the Congressional order, as well as the fact that HFTs have already demonstrated their potential to bring about negative consequences, the SEC has to move forward with the information that is available.

This paper is intended to aid in this process in three key ways. First, this paper will demonstrate that far from being a simple issue, where the general effect of a given phenomena is either good or bad (leaving policy makers only the task of dealing

¹⁰⁶ Senator Charles Schumer, “Letter to Chairmen Gensler and Schapiro et. al.”, Comments: Joint Committee on Economic, Banking, Finance and Judiciary Rules, <http://www.sec.gov/comments/265-26/265-26-9.pdf> (accessed September 12, 2013).

¹⁰⁷ Gould, 307-308.

¹⁰⁸ Ibid. 276, 304-305.

¹⁰⁹ Katherine Heires

¹¹⁰ Michael Howlett, M. Ramesh, Anthony Perl, *Studying Public Policy* (Oxford University Press, 2009), 141-142.

¹¹¹ It should be noted here that HFTs are not completely unregulated, they are subject to the regulations governing electronic exchanges and the national market system. See: Security Exchange Commission, NMS Plans, <http://www.sec.gov/rules/sro/nms.shtml> (Accessed September 12, 2013)

appropriately with the latter), HFTs have both positive and negative qualities (Section 3). Second, that due to the fact that HFT behavior is neither explicitly beneficial or detrimental, and that the objectives of regulation should be to promote the former while discouraging the latter (which satisfies the stated nominal objectives of the SEC itself, specifically promoting positive market quality). Finally this paper will analyze the proposals for further regulation of HFTs based up the literature reviewed and this schema of promoting positive HFT behaviour.

3. Literature Review

The literature on high-frequency trading is fairly sparse, which is not entirely surprising given its relatively recent evolution as a market phenomenon. “The rapid ascendancy of high-frequency trading has, at the very least, left most with an alarming lack of transparency into their practices and factual understanding of the costs and/or benefits they bring to the equity markets.”¹¹² It seems there has been insufficient time and resources applied to the research at the academic level for any real consensus to exist. This applies not only to the effects of HFTs but also to the methodology employed; there are significant differences in modeling, choice of metrics as well as data sources utilized the authors reviewed below. This is most likely due to the immaturity of the subject as a field of study. One of the conclusions drawn in this paper, that high-frequency trading has broad beneficial qualities but has the capability of contributing to major negative market movements are drawn from the findings of the authors’ works reviewed here. Judgments on the validity and appropriateness of their methods are not included here as that is not the focus of this paper, nor does it seem that enough information is available at present to engage in such a project.

Section 3.1 presents the findings of research showing that high-frequency trading is generally beneficial to market quality. Section 3.2 reviews literature that gives a concurring opinion on these effects but notes that there is a potential for HFTs to harm markets in the form of increased market fragmentation and aggressive liquidity consumption. Section 3.3 presents the findings of various research into the Flash Crash, making specific note of HFT and aggressive liquidity consumption.

¹¹² Security Exchange Commission, “Statement of Kevin Cronin, Security Exchange Commission, Microstructure Roundtable” (June 2, 2010). <http://www.sec.gov/comments/4-602/4602-11.pdf> (Accessed September 12, 2013).

3.1 HFTs: Positive Impact on Market Quality

The works contained in this section find that HFTs have significant positive effects on market quality, the general consensus here is that high-frequency trading improves market liquidity.¹¹³ A liquid market is one that is quite stable and is commonly characterized by a number of ready and willing buyers and sellers. High-frequency trading improves opportunities to match buyers and sellers, improving the rate of trading and the accuracy of prices. Sections 3.1.1 and 3.1.2 contain a summary of these findings. High-frequency trading can also be understood to improve the speed at which prices adjust (3.1.3 Price Discovery), generally lowering levels of market volatility (3.1.4) and the impact on prices of large trades (3.1.5).

3.1.1 Liquidity Provision

Hendershott, Jones and Menkveld¹¹⁴ examine the effects of algorithmic trading finding that it generally improve market liquidity.¹¹⁵ The authors use the rate of electronic messaging on the market as a proxy for algorithmic trading and compare it to time series data of the effective spreads of a sample of NYSE of stocks from February 2001 to December 2005.¹¹⁶ It difficult to determine whether or not a an algorithm is behind a given trade solely by the trader's identification number from an exchange, the authors attempt to gauge the nature of the trades based upon the frequency of the rate of electronic messaging. Computer algorithms would be able to send and receive messages about possible trading opportunities more expediently than human traders, hence the choice of electronic messaging as their proxy.

¹¹³ “ The degree to which an asset or security can be bought or sold in the market without affecting the asset's price. Liquidity is characterized by a high level of trading activity. Assets that can be easily bought or sold are known as liquid assets. . The ability to convert an asset to cash quickly. Also known as "marketability." From: Investopedia: Broker Terminology: "Liquidity Definition", from: <http://www.investopedia.com/terms/l/liquidity.asp> (Accessed March 12th, 2013)

¹¹⁴ Terrence Hendershott, Charles M. Jones, Albert J. Menkveld. "Does Algorithmic Trading Improve Liquidity?", *The Journal of Finance*, (Vol. 66, No. 1, February 2011, pp. 1-33).

¹¹⁵ Ibid. 3.

¹¹⁶ Ibid. 5-6.

As the auto-quote system was introduced on the NYSE, whereby the best bid and ask quotes are automatically disseminated¹¹⁷ (a significant aid to algorithmic traders), the authors' proxy for algorithmic trading was shown to have statistically significant relationships towards spreads, half- spreads, and 5- 30- minute spreads.¹¹⁸ Where a narrowing spread indicates improved liquidity, the increase in message trafficking on the market is positively correlated with such a narrowing process; specifically as auto-quote was introduced the effective spread of quotes was seen to drop.¹¹⁹ As information is more expediently disseminated to algorithmic traders, they are able to respond to market changes and update their orders more quickly, resulting in improved liquidity.¹²⁰ Expedious updating of orders, meaning the removal of stale or out-of-date quotes in a rapid fashion, benefits the market as a whole as traders are able to execute trades more efficiently.

In an associated work, Hendershott and Riordan look at HFT performance on the DAX,¹²¹ a series of electronic indices designed for statistical arbitrageurs and algorithmic traders provided by *Deutsche-Boerse*.¹²² The authors examine the average price algorithmic traders were at compared to their human counterparts within the bid-ask spread. Their findings show that ATs are trading within this spread more often than not a statistically significant level.¹²³ Generally: "...algorithmic traders consume liquidity when it is cheap and provide liquidity when it is expensive"¹²⁴ As AT traders are posting orders within the bid-ask spread, other trading parties have improved opportunities to trade close to the present price, both in buying and selling, which results in improved liquidity.

¹¹⁷ Ibid. 13.

¹¹⁸ Ibid. 20-21.

¹¹⁹ Ibid. 23.

¹²⁰ Ibid. 28, 30-31.

¹²¹ Terrence Hendershott, and Ryan Riordan, "Algorithmic Trading and Information", (July 6 2009, working paper).

¹²² Deutsche Börse: "Deutsche Börse Market Data- DAX Indices", http://deutsche-boerse.com/mda/dispatch/en/kir/gdb_navigation/mda/100_indices/100_dax_indices, (Accessed March 18th, 2013).

¹²³ Hendershott and Riordan, 18.

¹²⁴ Ibid.

The generally preferred mechanism for AT/HFTs are limit orders¹²⁵, whereby an order to buy or sell is executed when the stock reaches a certain price or better.¹²⁶ This system is a modification of the more traditional market maker role and inventory trading, a key provider of market liquidity.¹²⁷ Traders producing limit orders far from the current price are typically value investors, while those closer are liquidity traders attempting to profit from short-term price movements.¹²⁸ When algorithmic traders consistently issue limit orders near the current price at high-frequency, the number of opportunities are improved for buyers and sellers to find counterparties to complete a given trade. When there are significant order imbalances in the market, meaning that there are difficulties in matching buyers and sellers in the market, the level of liquidity drops (consider the discussion of the Flash Crash in Section 2.2).¹²⁹ Thus the mechanism by which high-frequency traders improve market liquidity is to increase the number trading opportunities near the current market price.

Foucault, Kadan and Kandel (2005) provide a formal model to examine this effect. The bid-ask spread is inversely correlated to the order arrival rate,¹³⁰ the faster orders come in to the limit-order books the smaller the bid-ask spread. Just as with the price updating mechanism discussed by Hendershott, Jones and Menkveld, a smaller bid-ask spread makes it easier for actors to find each other and trade with one another as the differences in prices between buyers and sellers is smaller. Foucault, Kadan and Kandel also note (2012) that the trading process inherently involves a certain level of cost, namely that of monitoring prices in order to find profitable opportunities.¹³¹ Trading

¹²⁵ Aldridge, 62-63.

¹²⁶ Securities Exchange Commission: "Limit Orders", <http://www.sec.gov/answers/limit.htm> (Accessed March 18th, 2013)

¹²⁷ Aldridge, 129-130, 133., Brogaard, 14.

¹²⁸ Aldridge, 133.

¹²⁹ Tarun Chordia, Richard Roll and Avanidhar Subrahmanyam, "Order Imbalance, Liquidity, and Market Returns", from: *Stock Market Liquidity: Implications for Market Microstructure and Asset Pricing*, François-Serge Lhabitant and Greg N. Gregoriou eds. (2008, John Wiley & Sons, Hoboken, New Jersey), 14.

¹³⁰ Thierry Foucault, Ohad Kadan, and Eugene Kandel, "Limit Order Book as a Market for Liquidity", from: *The Review of Financial Studies* (Vol. 18. No. 4, Winter 2005), 1194.

¹³¹ Ibid., "Liquidity Cycles and Make/Take Fees in Electronic Markets", (March 14, 2012). *Journal of Finance*, Forthcoming; EFA 2009 Bergen Meetings Paper. Available at SSRN: <http://ssrn.com/abstract=1342799>, (Accessed January 28,, 2013), 2-3.

opportunities are often fleeting, requiring significant effort in monitoring the market and looking for them. As Algorithmic trading increases the trading rate, it improves the number of trading opportunities for investors. Thus algorithmic trading significantly lowers market monitoring costs in general, improving the trading rate resulting in higher levels of liquidity.¹³²

3.1.2 Liquidity Provision and Market Changes

Chaboud et. al. examine the effect of AT on currency trading using minute by minute data from the EBS from 2006-2007.¹³³ One of the key questions they address is liquidity supply in terms of the release of public information¹³⁴, finding that algorithmic traders do not pull their liquidity provision in times of increased volatility following the release of important news¹³⁵. Simply put, as news that has a significant impact on currency trading markets is announced, human traders can be seen to have a tendency to slow their rate of trading in order to check to see the market's reaction. Generally, ATs do not "... shrink back from providing liquidity during the extended period of volatility that follows data releases."¹³⁶ This supports Irene Aldridge's claim that one of the benefits of high-frequency trades is that their computer executed algorithmic nature is spared the often detrimental effects of emotional reactions.¹³⁷

The concept of liquidity provision is perhaps the most important factor supporting the notion that HFTs have a positive market impact. For the purposes of the schema to be used in evaluation the regulatory proposals (Section 4), the discussion of the aspects of HFT behavior form the basis for the assertion of this paper that HFTs have a general positive effect on market quality. Thus some complexity arises when considering what exactly policy makers should do in regulating high-frequency trading. Simply focusing on the negative role they played in the Flash Crash (Section 2.2), could easily lead one

¹³² Ibid. 29.

¹³³ Chaboud et. al., 2.

¹³⁴ Ibid. 16.

¹³⁵ Ibid. 18.

¹³⁶ Ibid.

¹³⁷ Aldridge, 2.

to conclude that HFTs need to be impeded or outright prohibited. Such a decision by policy makers at the SEC would actually then run contrary to their objectives of promoting stable and efficient markets. Thus the ability for HFTs to be suppliers of liquidity to the market places should not be ignored. This also applies to the other commonly found positive effects of HFTs: improvements in price discovery (3.1.3) influences on volatility (3.1.4) and mitigating price impacts (3.1.5)

3.1.3 Price Discovery

Though HFTs have been found to provide liquidity, it is important to note that does not happen over all stocks, Aldridge notes that the most suitable trades for HFT strategies are in highly liquid stocks.¹³⁸ Examining data from the NASDAQ Jonathan Brogaard confirms this, finding that HFTs supplied liquidity in 35.5% of the trades in the average day, meaning that HFTs do target stocks that are already heavily traded.¹³⁹ Brogaard's findings are in a general accordance with the other authors in this section; HFTs play a significant role in providing liquidity in the bid-ask spread, providing the best quote 45% of the time, thereby acting as a significant market maker.¹⁴⁰ As with the findings of Hendershot and Riordan, Brogaard found that HFTs contribute significantly to the information carried in the price and the price discovery process; HFTs were found to play a statistically significant higher role in price discovery than non-HFT trades.¹⁴¹ With the thirty stocks making up the key indices for the DAX, 51% percent of price discovery came from ATs,¹⁴² which is a larger contribution than that of flesh-and-blood traders.¹⁴³ Efficient price discovery is important for market quality, as it allows traders and investors to make better judgments about buying and selling decisions by knowing the accuracy of prices.

¹³⁸ Ibid., 37.

¹³⁹ Brogaard, 24.

¹⁴⁰ Ibid. 42-43.

¹⁴¹ Ibid. 56.

¹⁴² Hendershott and Riordan, 18.

¹⁴³ Ibid. 22.

3.1.4 HFTs and Volatility

In terms of volatility, the consensus of authors in this section is that HFTs have a favourable effect on market volatility. Hendershott and Riordan state in their conclusion: “Contrary to conventional wisdom, we find no evidence of AT behaviour that would contribute to volatility.”¹⁴⁴ Chordia, Roll and Subrahmanyam looking at the Trade and Quote Data from the New York Stock Exchange from 1993-2003¹⁴⁵ found that intraday volatility has decreased in recent years, the cause of which they attribute to the increasing use of quantitative trading practices¹⁴⁶, a category to which HFTs belong. Brogaard found that HFTs had a significant impact in lowering volatility in 85 percent of the 120 NASDAQ stocks analyzed.¹⁴⁷ For high-frequency trades of currencies, Chaboud et. al. find that AT participation in the market lowers market volatility, for every increase in computer participation in the market of 1.5 percent, volatility is lowered by about a tenth of a percentage point.¹⁴⁸ While HFTs appear to have only a small impact in lowering volatility, it is important to note that from these studies, it is a negative impact rather than contributing to it.

3.1.5 Price Impacts

Besides acting as market makers, HFTs can also have a significant role in reducing price impacts. One of the key features of the algorithms utilized by high-frequency traders is to determine the optimal method of executing a trade, namely breaking up and sequencing a trade in order to minimize its price impact, preventing a sudden run-up or fall of the price of the stock or security.¹⁴⁹ According to Brogaard, the price impact of an average 1000 share trade would be 0.19 percent higher if HFTs were not involved.¹⁵⁰ Hendershott and Moulton found a similar effect for floor traders after the

¹⁴⁴ Ibid., 22.

¹⁴⁵ Tarun Chordia, Richard Roll and Avindhar Subrahmanyam, “Recent Trends in Trading Activity and Market Quality”, from *Journal of Financial Economics*, (Vol: 101, 2011), 245.

¹⁴⁶ Ibid. 261-262.

¹⁴⁷ Brogaard, 60.

¹⁴⁸ Chaboud et. al., 15.

¹⁴⁹ Aldridge, 16-17.

¹⁵⁰ Brogaard, 46.

introduction of the hybrid market on the NYSE.¹⁵¹ And as noted above, Chaboud et. al. found that ATs can improve liquidity in the period following the announcement of important news. HFT trades can provide improved liquidity during times of market stress, thereby limit the impact on prices of news due to a market overreaction. Using data from the electronic market for Swedish stock futures (OMX), Coppejans, Domowitz and Madhavan¹⁵² found that increases in market liquidity in an automated auction lessens overall future volatility.¹⁵³ From a slightly different perspective, Groth had similar findings when looking at *Deutsche Borse's* Xetra exchange system. In times of high volatility, humans provided less liquidity than algorithmic traders.¹⁵⁴

3.1.6 Summary and Implications of Section 3.1

Overall it would seem that high-frequency trading has important positive effects on market quality, namely: liquidity provision, improvements in price discovery and lower levels of volatility and price impacts. The works reviewed in this section form the assessment of the positive role high-frequency trading plays in the market that forms the “passive” portion of the evaluation schema for this paper. High-frequency trading, in general, has a positive effect on market quality, primarily in the form of improving the liquidity provision process (Sections 3.1.1 and 3.1.2) but also aids in price discovery (3.1.3), is associated with lower volatility (3.1.4) and reduces the impact of large trades and fundamental market movements on prices (3.1.5). These beneficial qualities clearly help market quality, and thus the SEC would be remiss to implement regulatory changes that would adversely impact these effects. It is, however, important to note that none of these works seem to be able to provide us any explication as to the role HFTs played in

¹⁵¹ Terrence Hendershott and Pamela C. Moulton, “Automation, Speed and Stock Market Quality, the NYSE’s Hybrid”, from: *Journal of Financial Markets* (Vol. 14, 2011), <http://faculty.haas.berkeley.edu/hender/Hybrid.pdf> , 597.

¹⁵² Mark Coppejans, Ian Domowitz and Anath Madhavan, “Liquidity in an Automated Auction” (Working paper, June 12, 2001), eBusiness Research Center, Pennsylvania State University, pg. 1.

¹⁵³ Ibid., 21-22.

¹⁵⁴ Sven S. Groth, “Does Algorithmic Trading Increase Volatility? Empirical Evidence from the Fully-Electronic Trading Platform Xetra”, Discussion Paper, Goethe University, (2011). http://www.futuresindustry.org/ptg/downloads/WorkingPaper_Algo_SvenGroth.pdf, 22.

the Flash Crash. In examining the next two sections we will see that there are important assumptions made by the authors in this section which may not necessarily always hold true (such as the instances of extreme market volatility like that which served as the proximate cause of the Flash Crash).

3.2 Cautionary/Neutral View of HFT

3.2.1 "Aggressive" vs. "Passive" Trading

In the work of the authors reviewed above it is important to note that HFTs and ATs are treated indiscriminately. This section takes a more nuanced approach and demonstrates that while HFTs are generally positive, they do have the potential to adversely affect market quality. Evangelos Benos and Satchit Sagade break down HFTs into "active" (or "aggressive") and "passive" varieties,¹⁵⁵ and examine a question of aggressiveness. Active HFTs are characterized by a higher ratio of volume executed by market or limit orders over the total trading volume,¹⁵⁶ the authors examine the role of these two categories of HFTs through 100 randomly selected stocks from the FTSE.¹⁵⁷ As with the work of Hendershot, Riordan, Brogaard; HFTs in general were found to contribute significantly to the price discovery process.¹⁵⁸ The authors also found that that HFTs are beneficial mechanisms in terms of conveying information, possessing a significantly higher level of information to noise ratio than other forms of trades.¹⁵⁹ However, on the matter of liquidity, aggressive HFTs were found to consume liquidity while passive ones were found to provide it.¹⁶⁰ In this case, passive HFTs provide liquidity by trading near the current market price, attempting to profit from small price adjustments. Aggressive HFTs "consume" liquidity by attempting to take a position

¹⁵⁵ Evangelos Benos and Satchit Sagade, "High-frequency Trading Behavior and Its Impact on Market Quality: Evidence from the UK Equity Market", (Working Paper No. 469, Bank of England, December 2012).

¹⁵⁶ Ibid. 1, 6.

¹⁵⁷ Ibid. 1, 3.

¹⁵⁸ Ibid. 17.

¹⁵⁹ Ibid. 21-22.

¹⁶⁰ Ibid. 20.

different from the current market trend, e.g., aggressive short selling or alteration of a large position. Examining the effect of HFTs on the European *Chi-X* exchange, Menkveld found the same effects for aggressive and passive HFTs.¹⁶¹ The negative effects can conceivably be magnified by the fact that ATs have a tendency to target the most liquid securities to begin with.¹⁶² Aggressive HFT orders would consume the liquidity being provided by other market participants. Zhang, in examining the Thompson Reuters institutional database¹⁶³ found that HFTs do contribute to more efficient price discovery¹⁶⁴, but seem to cause increased volatility.¹⁶⁵

Here we can begin to see some the impetus for regulation of HFTs, in the case of passive vs. aggressive it would be beneficial for policy makers to encourage the more passive HFTs and discourage the more detrimental aggressive variety. As noted above this division will serve as primary framework for analyzing possible regulation of HFT. The sections below further examine how HFTs may become aggressive and liquidity consumers.

¹⁶¹ Menkveld. Pg. 17.

¹⁶² Aldridge, pg. 37.

¹⁶³ Zhang, pg. 11.

¹⁶⁴ Ibid. 26.

¹⁶⁵ Ibid. 20-22.

3.2.2 Assumptions of Normality¹⁶⁶

As noted above, a key aspect of the authors reviewed in the first section are some unevaluated assumptions. Latteman et. al. agree with Hendershott and Riordan about the positive effects of HFT on the DAX.¹⁶⁷ However the authors note that most the work supporting the positive benefits of HFTs assume a level of normality, either within the functioning of the HFTs themselves or in the wider marketplace.¹⁶⁸ Lattemen et. al. show us that the question is not as straight forward as simply detecting the positive effects of HFTs. Given that abnormal conditions are not out-of-the-question for any market, the specific advantages and disadvantages of HFTs must be examined in context specific cases. This fact will rise to even higher salience in the portion discussing HFTs and the Flash-Crash, stress from events such an event may lead to the evaporation of the liquidity they provide.¹⁶⁹ HFTs seem likely to withdraw liquidity in times of stress such as the Flash-Crash, as well as run the risk of contributing to systemic risk, where the price of a security is driven in an unintended direction.¹⁷⁰

¹⁶⁶ For a basic discussion of the underlying assumptions used by algorithmic and high-frequency traders see: Andrew Kumeiga and Benjamin Edward Van Vliet. "Automated Finance: The Assumptions and Behavioral Aspects of Algorithmic Trading", *Journal of Behavioral Finance* (March 2012); for a more technical discussion of these assumptions and how they may be flawed: Paul Wilmott, "The Use, Misuse and Abuse of Mathematics in Finance" from *Philosophical Transactions: Mathematical, Physical and Engineering Science* (Vol 358, January 2000). High-frequency trading is crucially underpinned by complex mathematical models of market structure, and such models allow the for calculation and execution of profitable trading strategies. In order to construct these models, some assumptions have to be made, namely on issues of volume, depth and volatility. The 2008 financial crises proved to be an interesting challenge for algorithmic traders in general: "... during the recent financial crises, the large market volatility strongly affected the model estimation, leading to large estimation error, i.e., to a very large uncertainty about the mean and variance forecasts." – Massimiliano Caporin and Lorian Pelizzon, "Market Volatility, Optimal Portfolios and Naïve Asset Allocations", from: *Rethinking Valuation and Pricing Models*, Wehn et. al. eds., (Elsevier, 2012), 422.

¹⁶⁷ Lattenman et. al., pg. 98.

¹⁶⁸ Ibid.

¹⁶⁹ Ibid. 100.

¹⁷⁰ Gomber et. al. 45, 52-53.

3.2.3 HFTs as Middlemen

The more nuanced approach advocated by Latteman et. al. is taken by Jovanovic and Menkveld who examine the roles of HFTs as middlemen.¹⁷¹ On a general level they find that HFTs can positively contribute to overall liquidity supply.¹⁷² However, there is a significant problem if we conceive of them as middlemen, part of their job it is to convey market information to other traders. When late entrants arrive without the same level of overall information as other market participants, adverse selection costs are introduced, reducing overall market welfare.¹⁷³ The asymmetry can cause those late entrants to choose to purchase “bad” products on the market. Hence if there any impediment to the dissemination of information, the speed at which HFTs operate could seriously exacerbate adverse selection costs. The use of “dark liquidity pools” can be understood as a mechanism that would serve as such an impediment.

3.2.4 Dark Liquidity Pools

Gomber et. al. also examines HFTs as middle-men (as market-access intermediaries), noting that overall they enable market participants to “dramatically speed up the reception of market data, internal calculation procedures, order submission and reception of execution confirmations”¹⁷⁴ However the authors note there can be a significant problem with some of the mechanisms through which HFTs operate, namely dark pools. These are entities where “(t)he trading volume created by institutional orders that are unavailable to the public. The bulk of dark pool liquidity is represented by block trades facilitated away from the central exchanges.”¹⁷⁵ These entities are important as market participants’ indication of interest in a given trade is only made available to a certain subset of the trading community. The purpose of this is to: “...allow traders to

¹⁷¹ Boyan Jovanovic, and Albert J. Menkveld, “Middlemen in Limit-Order Markets”, (November 8, 2012). Western Finance Association (WFA), 2011. Available at SSRN: <http://ssrn.com/abstract=1624329>

¹⁷² Ibid. 20.

¹⁷³ Ibid. 6-7.

¹⁷⁴ Gomber et. al. pg. 6-7.

¹⁷⁵ Investopedia: Broker Terminology: “Dark Pool Liquidity Definition”, http://www.investopedia.com/terms/d/dark_pool_liquidity.asp (Accessed March 3, 2013).

buy or sell large orders without running the risk other traders will work out what is going on and put the price up, or down, to take advantage of the order.”¹⁷⁶ Gomber et. al. argue that the use of dark pools can dramatically distort the picture of available prices, as not all information is made immediately available to the open market,¹⁷⁷ a concern echoed by regulators and the Securities Exchange Commission.¹⁷⁸ As for the other effects of HFTs, the authors find that “... it is not pretentious to state that HFT has become a highly relevant source of market liquidity.”¹⁷⁹

3.2.5 Summary and Implications of Section 3.2

The work of Benos and Sagade forms the critical underpinning of the method that this will be used to evaluate the proposal for high-frequency trading for this paper. In general, HFTs function as passive and supply liquidity to the system improving market quality. But HFTS can also turn aggressive and consume liquidity. This section also laid out some other key problems caused by HFTs, namely the ability to increase adverse selection costs and distort information in the market. The following section further examines the ability of HFTs to act aggressively and harm market quality in examining literature on the Flash-Crash.

3.3 Critical View of HFTs – The Flash Crash

The rough consensus of academic literature reviewed so far on the effects of HFTs is positive,¹⁸⁰ HFTs generally speaking improve liquidity, aid in the price discovery process and can reduce levels of volatility. Much of the criticism levied against HFT traders cites the Flash-Crash as a serious side effect of these new trading techniques. Nathan Brown takes a highly critical view of dark pools¹⁸¹, arguing that the wider trading

¹⁷⁶ Financial Times Lexicon: “Dark Pools Definition”, Financial Times Website, <http://lexicon.ft.com/Term?term=dark-pools> (Accessed March 3, 2012)

¹⁷⁷ Gomber et. al. pg. 12.

¹⁷⁸ Brown, 217.

¹⁷⁹ Ibid. 38.

¹⁸⁰ Latteman et. al., pg. 95.

¹⁸¹ Brown, pg. 217-218.

public is made unaware of trades that have occurred, or will occur, and as a result are trading on the open market with outdated quotes. This contradicts some of the work noted above, where HFTs were found to improve the bid-ask updating process. In the case of the Flash Crash, where there may have been perfectly viable liquidity supplies, they were rendered inaccessible to portions of the market, thereby exacerbating the downward trend in the market.

3.3.1 The Flash-Crash and Market Fragmentation

Anath Madhavan raises another important issue with dark pools, that increased market fragmentation causes higher volatility. Following a similar line of reasoning to Gomber et. al., Madhavan argues that since increase of dark pools proliferates the number of venues through which traders can operate, whose imperfect linkages make prices more sensitive to volatility shocks.¹⁸² Using the Trade and Quote database for the NYSE leading up to the 6th of May 2010,¹⁸³ the author shows that the stocks that were experiencing trading fragmentation up to the Flash-Crash experienced the greatest shocks.¹⁸⁴ In a more general sense, we could interpret this to mean that high-frequency trader use of dark pools might increase the volatility of the stocks traded in those pools. This poses a significant challenge to all regulatory proposals; registered market maker obligations are meaningless here if dark pools increase volatility, which also applies to order submission restrictions. For the rebate fee system, we find similar problems as noted at the end of the cautionary/neutral paradigm.

3.3.2 Adverse Selection and the Flash Crash

David Easley et. al. examine the liquidity of the markets leading up to and through the Flash-Crash,¹⁸⁵ taking up the notion of the introduction of adverse selection discussed by Menkveld. Their metric is a measure of order flow toxicity (VPIN), which

¹⁸² Madhavan, pg. 21.

¹⁸³ Ibid. 23.

¹⁸⁴ Ibid. 32.

¹⁸⁵ Easley, et. al. pg. 3.

indicates the level of informed trading¹⁸⁶ occurring in the market.¹⁸⁷ When the VPIN is large, and market makers are on the wrong side of the trade with the informed traders, they become likely to undo their positions thus adding to the imbalance thereby potentially creating a crash. Looking at the E-mini S&P 500, the authors found a high VPIN metric suggesting a volatile situation, finally reaching its highest level only a few minutes before the start of the Flash Crash.¹⁸⁸ High-frequency traders acting as market makers were simply overwhelmed and thus withdrew from the market.¹⁸⁹ This narrative strongly follows the causal line established by the joint Commodity Futures Trading Commission and the Security Exchange Commission on the events of May 6th 2010” “...other firms that were still providing liquidity to the markets had to absorb continued order flow...(t)o the extent that this led to more concentrated price pressure ...”¹⁹⁰ As liquidity continued to evaporate from the market, the remaining market makers faced increased pressure, thereby continuing the downward plunge in prices.

3.3.3 Competition and Liquidity Consumption

Kirilenko et. al. use data from the June 2010 E-mini S&P 500 futures contract to reconstruct the actions of HFTs from May 3rd through May 6th, 2010.¹⁹¹ Their findings show an already tense market over concern surrounding the European sovereign debt crisis,¹⁹² implying there was unusual market behaviour in general. As volatility increased during the day, especially after 2:30 p.m when a major sell-off by a fundamental (value or long term investor) occurred¹⁹³, HFTs began to demonstrate an abnormally high level

¹⁸⁶ Traders making decisions based of off qualitative, industry, market or news based analysis. HFTs and ATs are largely uninformed seeking only to profit from statistical arbitrage opportunities.

¹⁸⁷ Easley, et. al. 5.

¹⁸⁸ Ibid. 7-8.

¹⁸⁹ Ibid. 9.

¹⁹⁰ U.S. Commodity Futures Trading Commission and Security Exchange Commission, *Findings Regarding the Market Events of May 6 2010: Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues*, September 30, 2010, 36.

¹⁹¹ Kirilenko et. al. pg. 11.

¹⁹² Ibid. 35.

¹⁹³ Ibid. 9, 36.

of aggressiveness.¹⁹⁴ Initially HFTs and other intermediary agents took up a significant portion of this sell-off, taking on temporary long positions. The result was HFT firms becoming more aggressive in order to reduce their inventories to offset this new position.¹⁹⁵ They began to compete for liquidity with fundamental and opportunistic traders who also consumed significant amounts of liquidity. And thus the Flash-Crash was born. It is also important to note that the authors specifically state that HFTs did not alter their behavior during the Flash-Crash¹⁹⁶, meaning the evaporation in liquidity observed is part of the interplay of the behaviors of HFTs and other market participants and not a function of a rogue algorithm or faulty trading strategies.

Kozham and Tham show us that the aggressiveness of HFTs in a situation like the Flash-Crash is a product of compensation for execution risk.¹⁹⁷ Arbitrageurs demand compensation for the risk associated with each trade (acquiring a long position to offset a short). In markets where liquidity is dropping, this demand for compensation increases,¹⁹⁸ hence the more aggressive stance by HFTs. Execution risk increases in illiquid markets as the impact on prices by trades becomes larger (a sell off significantly depreciates the price of a security in an illiquid market).¹⁹⁹ There are a limited number of profitable arbitrage opportunities in a given situation on the market, thus HFTs must compete with one another in order to seize the opportunities to offset the execution risk. The aggressive intake of liquidity by HFTs during a situation like the Flash-Crash is exacerbated by zero-sum competition between HFTs over available positions.

3.3.4 Summary and Implications of Section 3.3

The findings of Easley et al. (3.3.2) and Kirilenko et. al. (3.3.3) support the conclusions drawn by the Commodity Futures Trading Commission and the Security Exchange Commission on the Events of the Flash-Crash (2.2). Under conditions of

¹⁹⁴ Ibid. 15.

¹⁹⁵ Ibid. 36.

¹⁹⁶ Ibid. 25-26.

¹⁹⁷ Roman Kozham and Wing Wah Tham, "Execution Risk in High-frequency Arbitrage" (March 29, 2012) Available at SSRN: <http://ssrn.com/abstract=2030767>

¹⁹⁸ Ibid. 9, 11.

¹⁹⁹ Ibid. 18, 21.

heightened volatility, order toxicity and competition, HFTs rapidly begin to aggressively consume liquidity. This is precisely the effect that regulation for HFTs is intended to prevent. There is a secondary problem revealed in this literature: Section 3.3.1 elaborates on the problem of dark pools introduced in 3.2.4, where in the electronic venues sometimes utilized by HFTs have the potential to dramatically increase market volatility. Dark pools will be seen to be a problem for regulators in Section 4.

3.4. Literature Analysis

The work of Easley et. al. supports the general findings of the SEC/CFTC investigation into the Flash-Crash. The exceptionally high level of flow toxicity is a violation of the assumption normality of the market noted by Latteman et. al. It is then not hard to conceive of what happened next, increased volatility led to unanticipated HFT reactions to the market. As each HFT trader began liquidating their position to offset the changing market conditions laying short propositions off against long ones, it is clear that the unwinding process required high-frequency traders to post more aggressive limit orders thereby consuming liquidity.

The three main viewpoints contained in this literature review, while different in their individual assessments of the effects of high-frequency trading, can be coalesced into a general framework. All things being equal, we can understand HFTs to be beneficial to market performance in terms of general liquidity, efficiency in prices through shrinking bid-ask spreads and reduced volatility. This position seems to be the position of the majority of the academic research on the affects of ATs and HFTs.²⁰⁰ It is important to note that this point is not without some contention, each of the works reviewed above utilize different methods and different data in their analysis. It is also important to note the limited amount of research, and the views of the academic community could easily change as more research is done.

In asserting the positive impacts of HFTs on market quality is to hold normality as a stable condition of the marketplace. The authors holding the cautionary viewpoint

²⁰⁰ Gomber et. al., 33-34, 37.

alert us to the potential that given certain circumstances, these benefits disappear and HFTs take on a more negative role, something the authors discussing the Flash-Crash make note of. The market leading up to May 6th 2010 was increasingly volatile and subjected to abnormal stresses, which reached a tipping point just after 2:00 pm that day. Without other instances of major Flash-Crash-like events to compare May 6th to, it is impossible to know with certainty that HFTs did significantly contribute to the adverse market performance that day. That being said, the evidence provided by the breakdown of trading before and during the crash provided by Easley et. al. and Kirilenko et. al. are highly convincing.

For the remainder of this paper, the various qualities of high-frequency trading will be simplified into two categories. Following in the work of Benos and Sagade, this division²⁰¹ will be between “passive” HFT behaviour that is generally beneficial (Sections 3.1.1-3.1.5), and “aggressive” actions that can be highly detrimental to market quality (Sections 3.2.3-3.2.4, 3.3.1-3.3.3). The following section (4) will re-examine the proposals for further regulatory steps put forward in the introduction under the passive-aggressive understanding of HFTs. Specifically, what would the likely effect of each of the proposals be in promoting passive liquidity-providing HFT behaviour and/or discouraging the aggressive-liquidity taking behaviour noted during the Flash Crash.

²⁰¹ This view is becoming a more common approach in literature and research on high frequency trading. See: Steve Zwick, “High-frequency Trading: Good, Bad or Just Different, from *Futures*, (40:5, May 2011), 54.

4. High-Frequency Trading, the SEC and Regulation.

This section an overview of the challenges facing the policy makers who regulate U.S. Equities markers posed by HFTs with special attention to information problems as well as the notion of government failure. It will re-state the evaluation schema for this derived from literature reviewed above (Section 3) and then apply it to the HFT regulatory proposals discussed in Section 4.1

Given the extreme events of May 6th 2010, it is entirely fair to suppose that such an event requires a response from those who regulate the markets. One of the disastrous effects of those levels of instability is that of market distress: volatility in prices causes market actors to become hesitant to engage in what would normally be commonplace market interactions.²⁰² One of the stated objectives of the SEC is explicitly to prevent this sort of outcome, namely it is intended to engage in behavior that promotes order in the marketplace.²⁰³ This led to Senator Schumer's letter²⁰⁴ to the SEC requesting that the regulators responsible for the equities exchanges to start moving forward with changes in response to the Flash Crash. The SEC moved quickly with some initial steps, which addressed some of the issues exposed on May 6th but ultimately seem insufficient (see 6. Supplementary: The Initial SEC Response to the Flash Crash). The impetus for regulatory change in relation to the evolution of high-frequency trading was later folded into the batch of financial reforms made after the 2008 financial crisis; Section 967 "Commission Organizational Study and Reform" (a.2) of the Dodd-Frank Wall Street Reform and Consumer Protection Act. This provision requires

²⁰² Charles P. Kindleberger and Robert Z. Aliber, *Manias, Panics, and Crashes: A History of Financial Crises*, (Palgrave MacMillan, New York, 2011), 90-91.

²⁰³ Securities and Exchange Commission "The Investor's Advocate: How the SEC Protects Investors, Maintains Market Integrity and Facilitates Capital Formation"

²⁰⁴ Senator Charles Schumer, "Letter to Chairmen Gensler and Schapiro et. al."

the SEC²⁰⁵ to study: “(D) the effect of high-frequency trading and other technological advances on the market and what the SEC requires to monitor the effect of such trading and advances on the market”.²⁰⁶ The SEC was further ordered by congress to propose recommendations of legislative and regulatory changes based upon those findings.²⁰⁷ As noted above, public policy choices can be understood in three categories: positive (that alter the status quo), negative (that preserve the status quo) and the non-decision (where deviation is not considered). Based upon the political background described in the introduction and the legal imperative of Dodd-Frank, the negative and non-decisions are no longer options available. The SEC must move forward.

H.R. 4173 (Dodd-Frank) stipulates for the Security Exchange Commission to examine the effects of high-frequency trading, which should not be surprising given that it is a significant evolution of microstructure of the markets regulated by the SEC. It is important to note, however, that the Commodity Futures Trading Commission also fulfills a similar regulatory role to that of the SEC, initially being set up to mandate and regulate the commodities futures and options markets in the United States.²⁰⁸ Under Dodd-Frank, the role of the CFTC has expanded to additional market behavior, specifically the rule-making process for governing “swap” trades.²⁰⁹ High-frequency trading also plays a significant role on commodities markets, prompting the CFTC to examine the role of changing technology in those markets.²¹⁰

²⁰⁵ 111th Congress of the United States of America, H.R. 4173 “Dodd-Frank Wall Street Reform and Consumer Protection Act”. (H.R. 4173).

²⁰⁶ *Ibid.* 538.

²⁰⁷ *Ibid.* 538-539.

²⁰⁸ Commodity Futures Trading Commission: “Mission & Responsibilities”, CFTC Website, <http://www.cftc.gov/About/MissionResponsibilities/index.htm> (Accessed December 7, 2013).

²⁰⁹ *Ibid.*, “Dodd-Frank Act”, CFTC Website, <http://www.cftc.gov/LawRegulation/DoddFrankAct/index.htm> (Accessed December 7, 2013).

²¹⁰ *Ibid.*, “Technology Advisory Committee”, CFTC Website, <http://www.cftc.gov/About/CFTCCommittees/TechnologyAdvisory/index.htm> (Accessed December 7, 2013); and: “Event: Advisory Committee Meeting Sep. 12, 2013”, CFTC Website, http://www.cftc.gov/PressRoom/Events/opaevent_tac091213 (Accessed December 7, 2013).

In fact, staffs from the SEC and the CFTC were responsible for the official analysis of the Flash-Crash.²¹¹ Indeed they do function in a similar capacity across divergent markets. That being said, the purpose of this paper is to examine the regulator's response to the Flash-Crash, which as noted in Section 2.2, occurred primarily within equities markets (the Nasdaq and S&P 500), hence the focus on the SEC. Paring the SEC's role with the evolution of HFTs (rather than the CTFC), for this paper, also follows the general direction of regulatory changes occurring in the United States (as seen with Sec. 967 of Dodd-Frank). It is interesting to note that, until very recently the CTFC was mostly in a "fact-finding" mode, taking until October 30th, 2012 to even settle on a definition of high-frequency trading.²¹² As of very recently, the CTFC has begun considering some of the proposals reviewed in this paper in response to high-frequency trading, specifically a registered status (Table 1- 1. Market Maker Responsibilities) and a limit on the number of orders (Table 1- 3 Order Restriction Submissions).²¹³ It is certainly plausible that some of the lessons of this paper could be adapted and applied to the markets regulated by the CFTC, as the literature reviewed in Section 3 is about the general effects of high-frequency trading. However, the secondary narrative (Flash-Crash) used to inform the evaluation of regulatory proposals in this paper, is derived from events on the equities (rather than those of the commodity markets). Hence, in terms of possible regulations on HFTs, this paper will be examining the problem from the perspective of the SEC.

In compliance with Dodd-Frank, the SEC regularly submits reports on their efforts to conform with the legislation passed by Congress. The SEC has begun to implement: (1) special investigative operations into areas of market abuse including by heavy-

²¹¹ U.S. CTFC and SEC: *Findings Regarding the Market Events of May 6 2010: Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues*

²¹² CTFC Technology Advisory Committee, Sub-Committee on Automated and High-Frequency Trading- Working Group 1, Presentation, (October 30th, 2012), from: http://www.cftc.gov/ucm/groups/public/@newsroom/documents/file/tac103012_wg1.pdf (Accessed December 7, 2013).

²¹³ Matthew Phillips, "The CFTC is Beating the SEC on Speed-Trading Rules", from Bloomberg Businessweek Website, (September 13, 2013), <http://www.businessweek.com/articles/2013-09-13/the-cftc-is-beating-the-sec-on-speed-trading-rules> (Accessed December 7, 2013).

volume computer driven trades²¹⁴, and detailed study on “the effect of technology on the securities markets (e.g., the effect of high-frequency trading on the market)”²¹⁵. In none of the available SEC reports to Congress is there any indication that the SEC is prepared to state what regulations (if any) need to be put forward in response the evolution of high-frequency trading. Simply put, it would seem that the SEC is still in the information gathering stage.²¹⁶ Combined with another fact: the results of an SEC examination of the effects of HFTs, prior to May 6th, which addressed a divergent issue (namely the “fairness” of the emerging novel microstructure)²¹⁷; it seems entirely fair to assert that the SEC has shown combination of the inability to demonstrate an adequate understanding of rapid change in market microstructure, as well as a definite ability to cope with such changes. This is reinforced by the simple face of the jarring events of May 6th and the SEC’s ineffectual response immediately after (See Section 6).

As noted above, the literature on high-frequency trading is sparse, and lacks methodological uniformity. The inevitable result of this is the fact that our current

²¹⁴ Security Exchange Commission, “Report on the Implementations of SEC Organizational Reform Recommendations” 2nd Report, (March 30, 2012), from: <http://www.sec.gov/news/studies/2012/secorgreformreport-2012-df967.pdf> (Accessed December 7, 2013).

²¹⁵ Ibid, “Report on the Implementations of SEC Organizational Reform Recommendations”, 3rd Report, (October 17, 2012), from: <http://www.sec.gov/news/studies/2012/sec-organizational-reform-recommendations-101712.pdf> (Accessed December 7, 2013).

²¹⁶ Given the lack of progress, it would not be inappropriate to suggest that while demonstrating prudence, it also appears to show either an unwillingness to understand the evolution of the market place, or that the SEC has yet to muster the resources in order to give a proper examination.

²¹⁷ Prior to the events of the Flash Crash, the SEC had engaged in a study on HFTs but in terms of fairness to the markets rather than the effects of HFTs on market quality. The SEC was busy attempting to determine whether HFTs posed an unfair advantage to certain market participants [James A. Brigagliano, “Testimony Concerning Dark Pools, Flash Orders, High Frequency Trading, and Other Market Structural Issues”, from Security and Exchange Commission, (October 28, 2009), from: <http://www.sec.gov/news/testimony/2009/ts102809jab.htm> (Accessed December 7, 2013); and Security Exchange Commission Concept Release, 17 CFR Part 242, Release No. 34-61358; File No. S7-02-10, (January 14, 2010), from: <http://www.sec.gov/rules/concept/2010/34-61358.pdf> (Accessed December 7, 2013)]. To borrow an old colloquialism in their defense, “hindsight is always 20/20”. The SEC should not necessarily be faulted for failing to see the potential for HFTs to negatively affect market quality, but the fact should be taken as a consideration that a government body such as the SEC might not be able to garner the requisite information in order to engage in effective regulation (in this case exacerbated by the novelty of the innovation of HFTs).

understanding of HFTs and the changing face of market structure is not only incomplete, but also very limited. This leaves the SEC with a severe problem, how can any policy maker engage effective regulatory steps when they do not fully understand the problem being addressed?²¹⁸ The prudent decision would almost certainly to wait until more information is available (the regulatory non-decision).²¹⁹ The SEC already engaged in a round of regulatory changes that are insufficient to deal with another Flash-Crash (Section 6. Supplementary), repeating that process over again would likely serve only to waste time and capital. In a broader sense, inappropriate policy-making can result in “government failure”²²⁰ the policy-based-cousin to the better-known market failure. “Non-market [meaning government action] remedies ‘fail’ to the extent that they too result in outcomes that depart from the efficiency or distributional goals by which market outcomes are judged to fail”²²¹, meaning that the choice by governments to intervene in economic activity causes a more inefficient allocation of goods and resources that would occur without that intervention. In this case, actions taken by the SEC that inadvertently causes significant harm to market efficiency in its pursuit of preventing or mitigating another Flash-Crash would constitute a case of government failure.

The rationale for intervention occurs when the characteristics of the market significantly depart from the “textbook version of perfect markets”.²²² However, as noted

²¹⁸ One of the principle methods by which the SEC garners information in order to inform their rulemaking is through the SEC comment system: individual proposals or conceptual issues are offered by the SEC for public comment (Lavelle, 124). Through this system, the SEC can gain not only input from industry professionals but also gauge their likely reaction to any regulatory course. Given the lack of understanding of high-frequency trading, combined with the sometime unhelpful nature of the finance sector on questions (Connaughton 167, 170), it is not surprising that this system has not been as beneficial on the matter of HFTs as it may be in other areas.

²¹⁹ This course of action is not without its own problems. Further study is likely to add to the literature on the positive effects of HFTs as well as a more detailed picture of the events of the Flash-Crash. What would be optimal is to have more information on what sort of events trigger such a crash, something that would almost be impossible to gain without future Flash-Crashes. Simply waiting around might not allow the SEC to create effective legislation. In the case of another crash occurring, one would then be forced to ask why the SEC didn’t try to prevent such a costly market event.

²²⁰ Charles Wolf Jr., *Markets or Governments: Choosing Between Imperfect Alternatives*, (The MIT Press, 1993, Cambridge Massachusetts).

²²¹ Ibid., “A Theory of Non-Market Failures”, from *The Public Interest* (Spring, 1979), 120

²²² Ibid., 117.

by Wolf there are some noted problems once governments begin to act upon this rationale. First, that bureaucracy is often hypersensitive to market short-comings and regulators often believe they can solve these short-comings.²²³ Second, the impetus for intervention comes from non-market demand (meaning public political pressure), which is often excessive as it responds to perceived market failure rather than the actual qualities observed.²²⁴ Consider the topic being examined by this paper, much of the discussion of the negative qualities of HFTs are derived from the Flash-Crash (Section 3.3), but these works only address the role HFTs in the crash and do not address the broader of question of whether or not there was an actual failure of the market in terms of HFTs. “As public awareness of the inadequacies of market outcomes grows, demands for remedial action intensify. Dissatisfaction with existing circumstances may result in misperceiving the cause as market failure.”²²⁵ This raises an important question whether or not intervention in the form of restricting HFTs is truly warranted based upon this demand.²²⁶ Finally, the market demand for intervention often drives non-market participants to engage in the practice of intervention before adequate information is available.²²⁷ As noted by Le Grand, theoretically, a properly motivated and informed²²⁸

²²³ Wolf, *Markets or Governments*, 46-47.

²²⁴ *Ibid.*, 48-51.

²²⁵ *Ibid.* 66.

²²⁶ While the Flash-Crash was certainly a spectacular and frightening market event, it is important to remember that the plummet in prices was followed by a rapid recovery. Out of the 998.5 point plunge on May 6th, near 600 points were recovered by the end of the trading day, the Dow was down just 3.2% on the day [Alexandra Twin, CNN: “Glitches Send Dow on Wild Ride”, (May 6th, 2010)] This is only the 39th worst day for the history of the Dow Jones Industrial [Wall Street Journal, Market Watch: “The Dow’s 50 Worst Days”], hence it can be argued that the Flash-Crash was not as serious as some have made it out to be and that much of the concern over the Crash and HFTs by the SEC might just be the result of popular demand rather than rational understanding. “The notion that the Flash-Crash arose from an unlikely confluence... is reassuring because it suggests the chance of a recurrence is very low” (Madhavan, 22). That being said, there is some work to support the notion that HFTs are contributing to errant market events, see Johnson et. al., “Financial Black Swans Driven by Ultrafast Machine Ecology”.

²²⁷ Wolf, *Markets or Governments*, 80; Wolf, “A Theory of Non-Market Failures”, 120.

²²⁸ The information aspect here is crucial. Given the inadequate SEC response to the Flash-Crash, combined with the lack of information on high-frequency trading, one of the common methods by which the SEC garners information, the comments submitted under the rulemaking system [Security Exchange Commission, “How to Submit Comments”, from: <http://www.sec.gov/rules/submitcomments.htm> (Accessed December 7, 2013)] has been insufficient to guarantee an informed regulator.

government could achieve market efficiency through regulation, but are often faced with severe impediments in collecting the proper information (and thus are faced with government failure)²²⁹. This is clearly the case for the immediate SEC response (Section 6. Supplementary) and also holds true when considering the regulatory proposals being examined in this paper.

Yet waiting for more information is a course of action is not completely open to the SEC on this issue being that they have been ordered to put forward regulations specifically designed to deal with the effects of HFTs.²³⁰ These policy makers must move forward with the information available, a process that this paper is intended to inform and aid. In terms of government failure, where excessive or “heavy” regulation can adversely affect market dynamic efficiency²³¹ (as will be seen below in relation to the proposals outlined in Table 1), the intent of this paper is to aid regulators in choosing between policy options with the intent of minimizing the distorting effects on the market while still being effective. This should then minimize the chance for government failure.

Overall this paper has noted that HFTs can have both positive and negative effects. The division between passive and aggressive behavior is important not only for understanding the various effects that HFTs can have on the market but also for regulation. Since the role of the SEC is to “...protect investors, maintain fair, orderly and efficient markets and facilitate capital formation”²³², protecting the markets from the negative effects of high-frequency trading and another Flash-Crash like event is clearly an imperative for regulators, the framework and proposals for regulation should not simply be intended to be an impediment to HFTs. Given the positive effects of HFTs noted in section 3.1, the SEC would be remiss to simply attempt to impede or limit high-frequency trading, as this would violate their role in maintaining efficient markets. The ability of high-frequency traders to provide liquidity is clearly helping market quality. Thus, the position of this paper to this point can be articulated as the following schema:

²²⁹ Julian Le Grand, “The Theory of Government Failure”, from: *British Journal of Political Science*, (Vol. 21, 1991), 438.

²³⁰ See discussion above on Dodd-Frank.

²³¹ Le Grand, 439.

²³² Securities and Exchange Commission “The Investor’s Advocate: How the SEC Protects Investors, Maintains Market Integrity and Facilitates Capital Formation”

Any efforts taken by the SEC in relation to regulating high-frequency trading should be done with (1) the objective of limiting or preventing aggressive (liquidity consuming) behavior without (2) harming or impeding the ability for HFTs to function in a passive (liquidity providing) manner. The following sections evaluate the proposals outlined in Table 1 (and examined more in-depth below) with this schema in mind.

4.1 Regulatory Proposals

This section contains an overview of the four categories of regulation noted in Table 1, reviewing their intention in relation to the general market as well a Flash-Crash like event. It should be noted that these categories are only a general examination of possible regulatory options, for further detail on structure and specifics for these types of proposals can be found in the comments submitted to the SEC in relation to a review of equity market structure in the US.²³³

The market maker obligation (Table 1.1) entails a legal restriction on the behavior of HFTs. A market maker is a firm that holds a certain number of shares of a given stock or security and displays simultaneous buy- and sell- quotes for the purpose of general liquidity provision to the market.²³⁴ By constantly posting quotes and taking orders, market makers improve market efficiency by allowing those interested in buying and selling to easily find a counterparty (hence “making” a market for a given stock or security). Specifically in relation to a Flash-Crash like event, HFTs registered as market makers would be obliged to provide liquidity in times of increased market stress.²³⁵ A related set of proposals call for incentives for HFTs to behave as market makers (Table 1.2). This sort of regulation would rely improved incentives in the form of rebates for

²³³ Security Exchange Commission, “Comments on Concept Release on Equity Market Structure” (Release No. 34-61358; File No. S7-02-10), available at: <http://www.sec.gov/comments/s7-02-10/s70210.shtml> (Accessed February 23, 2013).

²³⁴ Investopedia, “Definition of Market Maker”, from: <http://www.investopedia.com/terms/m/marketmaker.asp> (Accessed February 22, 2013.)

²³⁵ Shapiro, “Strengthening Our Market Equity Structure”, NYSE Euronext U.S. Equities “Designated Market Makers, <http://usequities.nyx.com/listings/dmms> (Accessed September 25, 2013).

liquidity provision.²³⁶ Rebates are fees assessed on transactions where the party that is the liquidity taker charged a small transaction fee per share, part of which is sent to the party that is the liquidity provider.²³⁷ The purpose here is to provide some incentive for traders not simply withdraw liquidity from the markets in seeking profit maximization. Such fees can be a major source of income for any market maker or trader. "...HFTs make an average profit of about \$0.001 per share, so the typical rebate of \$0.002 is significant. If an HFT systematically earns rebates, the benefits quickly add up."²³⁸ Thus improving rebates for liquidity provision should be followed by HFTs engaging in trades that provide liquidity.

The third set of proposals relies on restrictions on how orders are submitted for processing within the market system. Restrictions on the minimum time an order can be posted (Table. 1.3.A) is a requirement that orders stay posted for a specific period of time.²³⁹ There have been criticisms of the effect of HFTs by some more fundamental investors²⁴⁰: "They also generate and submit vast amounts of orders that are cancelled shortly after submission. By some accounts as much as 90% of the orders generated by some high-frequency traders are subsequently cancelled."²⁴¹ This poses a potential problem to other market participants who wish to gauge the depths of the liquidity in the market, or may be frustrated by the fact that a quoted price can no longer be traded at.²⁴² During the Flash Crash, cancellation of posted orders on the buy-side contributed significantly to the lack of liquidity between 2:30pm and 3:00pm.²⁴³ Here is a situation where as prices began to fall, orders were cancelled as HFTs struggled to keep up with changing market conditions, and the cancelling of those orders further added to market imbalances driving prices down.

²³⁶ Barrales 1249.

²³⁷ NYSE Euronext, News Releases: "NYSE and NYSE Arca Announce Changes in Equities Transaction Pricing Effective March 1.", from: <http://www.nyse.com/press/1233573357875.html> (Accessed September 19, 2013).

²³⁸ Barrales, 1226.

²³⁹ Ibid, 1249-50.

²⁴⁰ *ibid.*

²⁴¹ Security Exchange Commission, "Statement of Kevin Cronin, Security Exchange Commission, Microstructure Roundtable" (June 2, 2010).

²⁴² Barrales 1250.

²⁴³ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 32-35.

The second proposal in this category (Table 1.3.B) requires a limit on the number of orders that can be posted in a given period. Carol Clark argues that such a restriction would prevent a trader from flooding the market with orders, which in turn allows orders to be more easily matched and filled by electronic exchanges. The overall effect of this would be to allow market participants to better understand their position through making information dissemination more efficient. In relation to HFT practices, this would specifically address the behavior known as quote stuffing: “A tactic of quickly entering and withdrawing large orders in an attempt to flood the market with quotes that competitors have to process, thus causing them to lose their competitive edge in high-frequency trading.”²⁴⁴ The SEC noted that during the Flash Crash, a most firms began to limit their exposure to the market because of data and quote concerns.²⁴⁵ Firms experienced delays in processing this data for a number of reasons, one of the primary ones being quote stuffing.²⁴⁶ The last set of proposals in this section (1.3.C) is a limit on the submission of orders based upon a price range.²⁴⁷ Orders submitted outside of a given range would be immediately cancelled by the exchange itself, before ever allowing them to be fully posted, arguably preventing volatile shifts in prices by limiting the range in which trades can occur.²⁴⁸ This range is calculated as an average over the previous 5 minutes. Thus in the case of the Flash Crash, the precipitous price decline that occurred in less than a two minutes would almost certainly have been prevented, the trades that did occur well below the market average of a few minutes prior to 2:45 p.m. would have been immediately cancelled, arguably slowing or preventing the crash. The initial sell off by the fundamental trader that triggered the Crash, a trade calculated to run at 9% below the market²⁴⁹, which is well outside the 5% threshold by the SEC²⁵⁰ would have also been cancelled. The final proposal, that of a Financial Transaction Tax (Table 1.4), calls for the exaction of a small fee of 3 basis points on any financial transaction over \$100 in

²⁴⁴ Investopedia, Broker Terminology: “Quote Stuffing”, from:

<http://www.investopedia.com/terms/q/quote-stuffing.asp> (Accessed September 23 2013)

²⁴⁵ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 35-36.

²⁴⁶ *Ibid.*, 79.

²⁴⁷ Gould, 316-317.

²⁴⁸ *Ibid.* 317.

²⁴⁹ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 2.

²⁵⁰ Security Exchange Commission, “SEC Approves Proposals to Address Extraordinary Volatility in Individual Stocks and Broader Stock Market”

value on the exchanges.²⁵¹ The general purpose of this would be to “slow” down the markets by eliminating the profitability HFT trading on small margins.

The SEC thus has several distinct policy options for dealing with the effects of high-frequency trading. From the overview above, each clearly addresses various aspects of HFTs as well as arguably could prevent the HFT behavior observed during the Flash-Crash. Now the question arises, which of these (or combination thereof) should the SEC chose to pursue? To phrase the question another way, which of these best allows the SEC to promote “orderly and efficient markets”? Simply looking at the role of HFTs during the Flash-Crash almost certainly leads to the conclusion that HFTs behavior should be severely impeded, curtailed or outright banned. But this approach would be in error in the pursuit of orderly and efficient markets. To answer this question proposed above, this paper will examine these four regulatory proposals in light of the findings of the literature reviewed above (Section 3).

4.2 HFTs as Market Makers

As noted above (Section 4.1) the general principle behind this sort of regulation is to limit the potential for aggressive HFT behavior would be an obligation for HFTs registered as market makers to provide liquidity in times of increased market stress²⁵², something that would have prevented HFTs from withdrawing from the market as some did during the Flash-Crash.²⁵³ Following the events of May 6th 2010, the SEC has stated an increased interest in market making and to encourage such traders to further act in a manner in accordance with the principle of market stability.²⁵⁴ The rationale often given for imposing these sort of restrictions on HFTs is that trading firms with the best market access “should be subject to obligations to trade in ways that support the stability and

²⁵¹ Office of Senator Tom Harkin, Press Release.

²⁵² Shapiro, “Strengthening Our Market Equity Structure”, NYSE Euronext U.S. Equities “Designated Market Makers, <http://usequities.nyx.com/listings/dmms> (Accessed September 25, 2013).

²⁵³ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 45.

²⁵⁴ Gould, 321.

fairness of the markets.”²⁵⁵ HFTs often utilize a principle called *co-location*, locating servers and computers as near to the exchanges as possible in order to minimize lag time in communication and maximize responsiveness to the market.²⁵⁶ Co-location is usually facilitated by the exchanges themselves, offering market participants the ability to house servers and equipment directly in (or immediately near) the physical premise of the exchanges themselves.²⁵⁷ Heightened market maker regulations call for users of these services to register as market makers and to be subjected to legal obligations, some of the most high-frequency of HFTs would be legally obligated to engage in passive liquidity provision and not allowed to exacerbate negative market movements. In terms on the general effect on the market, there should be not much change for the role HFTs play, Barrales notes that the vast majority of them already basically function as market makers²⁵⁸ which in accordance with the findings of Brogaard on the typical behavior of HFTs²⁵⁹ (noted above section 3.1.3). Thus this proposal would not seem to disrupt the passive role HFTs play with providing liquidity. On the issue of aggression, where by definition, HFTs consume liquidity, an HFT registered as a market maker would then be violating its obligations and would be subjected to punishments by regulators. In a future Flash-Crash like event, HFTs would not be able to pull away and would be obliged to stand and provide liquidity no matter the direction of the market.²⁶⁰

From this perspective, imposing market maker obligations on HFTs appears to be an excellent tool for limiting the potential for aggressive HFTs while having little or no effect on their passive behavior. This is presuming that HFTs continue to use co-location services once the obligation is put in place, a fact that seems far from certain. As noted above, the SEC made special note of how some high-frequency traders began to pull away from the market on the afternoon of May 6, 2010 (in order to avoid further

²⁵⁵ Shapiro, “Strengthening Our Market Equity Structure”.

²⁵⁶ Brown, 227, Gould 287.

²⁵⁷ Nasdaq QMX “Co-Location”, from: <http://www.nasdaqtrader.com/Trader.aspx?id=colo> (Accessed September 25, 2013), and Securities and Exchange Commission, “Self-Regulatory Organizations: Chicago Board Options Exchange Inc.; Notice of Filing Proposed Rule Change Relating to Co-location Service Fees” (Release No. 34.61489), from: <http://www.sec.gov/rules/sro/cboe/2010/34-61489.pdf> (Accessed September 25, 2013).

²⁵⁸ Barrales, 1220.

²⁵⁹ Brogaard, 42-43.

²⁶⁰ Barrales, 1247, Gould, 1252.

losses). This raises the question, if such traders are going to be told they must register as market makers (and would not be able to pull away from the market), how many would still use the co-location services provided? Co-location is an important tool for high-frequency traders something that allows a trader to gain an advantage in speed, by being able to access the market with lower latency, but not a necessity for HFT in and of itself.²⁶¹ Given this, simply relying on co-location services to corral HFTs into market maker obligations may backfire as firms do not wish to deal with such obligations. In this eventuality, imposing such an obligation might indeed harm passive HFT behavior by driving some HFT actors to other positions (possibly dark pools or other 3rd party services)²⁶², reducing their reaction times and thus lowering their ability to contribute to positive market quality²⁶³ as reviewed in section 3.1. Dark pools present a second problem here, namely that they have been shown to distort prices and other information due to increased market fragmentation (Sections 3.2.4 and 3.3.1). Any action that moves HFTs into dark pools would also then violate the 2nd portion of the schema, namely that of the objective being to limit the negative or aggressive portion of HFT behavior.

There is a further limitation to the effect of this proposal, one that can be exposed by careful examination of the Flash-Crash. While some HFTs did pull out of the market, the rest continued to trade and, for the most part, were functioning as market makers during the crash.²⁶⁴ After the initial sell off that triggered the crash began to be processed, HFTs began to rapidly buy and resell the same inventory over and over again²⁶⁵ furthering order imbalances²⁶⁶ where sellers were outnumbering buyers and a

²⁶¹ Netherlands Authority for the Financial Markets, “High Frequency Trading: The Application of Advanced Trading Technology in the European Marketplace”, available at: <http://www.afm.nl/~media/files/rapport/2010/hft-report-engels.ashx> ,(Accessed September 29, 2013), 16-18.

²⁶² Barrales, 1252.

²⁶³ Troy A. Paredes, “Speech By SEC Commissioner: Remarks at the Security Traders Association 77th Annual Conference and Business Meeting” (September 24, 2010), Available at: <http://www.sec.gov/news/speech/2010/spch092410tap.htm> (Accessed September 14, 2013).

²⁶⁴ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 14.

²⁶⁵ *Ibid.*, 3.

²⁶⁶ See Easley et. al.

there was a general withdrawal of liquidity from the marketplace.²⁶⁷ In this sort of situation the market maker is basically useless for providing liquidity as only one side of the market book would be active. As noted above, a heightened market maker obligation would likely have prevented some of HFTs from withdrawing from the market but it seems very unlikely it would have done little to float liquidity when most traders are focusing on the sell side.

The notion of imposing market maker obligations on HFTs would, on the surface appear to satisfy the objectives of the SEC here, encouraging stable markets through promoting passive liquidity provision and limiting aggressiveness. But the method by which this is most easily accomplished carries the risk that it would drive some HFTs into higher-latency positions, limiting their ability to react expediently to the market. In terms of a Flash-Crash-like situation, it would keep some HFTs on the market but would not seemingly accomplish enough to say it would have prevented the crash. In summary it would seem that this sort of proposal has both negative and positive effects as well as some rather severe limitations. In order to determine the over net benefit of it, the SEC would have to carefully consider just how many HFTs would still keep using co-location services, and if its worth the lost market quality if enough firms move away into higher-latency positions or dark pools.

4.3 Incentives for Market Maker Behaviour

Where the type of proposal noted above attempted to force HFTs to register as market makers, this section deals with providing incentives for them to occupy that role. This is accomplished by providing very small rebates for trades that provide liquidity to the marketplace. Compared to the proposal above, the benefits and implications of this sort of regulation are clear. This system relies solely on economic incentives rather than legal proscriptions and the ensuing regulatory pressure of forced market making. The entire concept of rebate fees follows exceptionally closely the evaluation schema set out in this paper, that the SEC should be working towards promoting passive HFT behaviour while attempting to mitigate or prevent them from acting aggressively. Rebate fees, by

²⁶⁷ Ibid. 35-36.

their very nature promote liquidity provision, and hence passivity among HFTs.²⁶⁸ There are, however, significant shortcomings here. First, there is virtually nothing in this proposal that would seriously impede aggressive HFTs during a crash. The massive price drops experienced during May 6th would certainly force HFTs to trade on market movement (attempting to unload inventory that is rapidly losing value) as HFTs are self interested just as any other actor on the market²⁶⁹. The relatively microscopic incentive provided by these fees would be overshadowed by the volatility of the situation. High-frequency traders would still be free to pull out of the market as well.²⁷⁰ Thus not only would this sort of regulatory change not prevent aggressive behaviour in the first place, its ability to promote liquidity provision is very limited during a another Flash Crash. Given the volume that HFTs deal in, increasing the rebates for liquidity provision would be a significant cost to the market²⁷¹ and would not necessarily be justified if the firms pulled out in cases of extreme volatility.²⁷² This sort of regulatory change only satisfies the 2nd portion of the schema, while failing to address the 1st completely.

4.4 Order Submission Restrictions

4.4.1 Order Submission Restrictions: Minimum Post Time

The first of these type restrictions is a requirement that orders stay posted for a specific period of time.²⁷³ As noted above, the speed at which HFTs submit and cancel orders can have some serious consequences for the market. In the case of the Flash-Crash, rapid cancellation of buy-orders contributed to the lack of liquidity once prices began to fall.²⁷⁴ This sort of regulation would require that any order submitted stay posted for a minimum period, allowing for participants to better understand liquidity

²⁶⁸ High-frequency traders typically have relied on collecting these fees as a method of supplementing profitability from trading on very small margins – Barrales, 1226.

²⁶⁹ Gould, 321-322.

²⁷⁰ Barrales. 1256.

²⁷¹ Jovanovic and Menkveld, 35.

²⁷² Ibid 1255.

²⁷³ Ibid, 1249-50.

²⁷⁴ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 32-35.

depth and market movements. In the case of the Flash Crash, institutional and fundamental traders would likely have less inclined to withdraw from the market if they could be certain that the posted orders would not be immediately cancelled, thus providing greater incentive to stay in the market and stem some of the loss of liquidity. High-frequency traders would have been limited in their ability to move in and out of positions, limiting the “hot-potato” effect of rapidly moving excess sell-side orders between them²⁷⁵, arguably mitigating some of the aggressive HFT behavior observed. In a broader sense though, this sort of proposal is less intended to deal with market quality in times of stress and to do more generally with overall equity structure, that the speed at which HFTs can submit and cancel orders puts them at an advantage over fundamental or institutional investors.²⁷⁶ A minimum post time would seemingly serve as a metronome, keeping a steady pace on the market, limiting the ability of HFTs to change the tempo and, possibly, direction of the market.

As noted above, this sort of restriction would have served to stem some of the loss of liquidity during the Flash Crash, mitigating some of the aggressive behavior of HFTs. Given the schema of this paper and the objectives of the SEC, while this certainly serves the purpose of improving market quality in a case such as the Flash Crash (filling the 1st requirement of the schema), the notion of limiting the market in terms of speed, thereby impeding HFTs, violates the notion of promoting market efficiency (violating the 2nd) Where the literature reviewed in section 3.1 of this paper identified several key ways in which high-frequency trading improves market structure (general liquidity provision, aiding price discovery, lowering volatility and reducing price impacts), the notion of restricting HFTs would then seem to be detrimental to market quality and efficiency. This type of submission order restriction would seem to have too many negative, and too few positive consequences to warrant its implementation.

²⁷⁵ Ibid. 3.

²⁷⁶ Security Exchange Commission, “Statement of Kevin Cronin, Security Exchange Commission, Microstructure Roundtable” (June 2, 2010).

4.4.2 Order Submission Restrictions: Limits on the Number of Orders That Can Be Submitted

A restriction on the number of quotes for orders that can be posted in a given period would almost certainly make real-time data analysis of various market participants simpler and more efficient, which should allow the broader trading public to better understand the movements on the market, arguably improving market quality.²⁷⁷ In the case of the Flash-Crash, more efficient data processing would have likely led to fewer market participants pulling back from the market, thereby lessening the overall loss in liquidity (see Section 2.2). However, this somewhat contradicts the findings of Hendershott, Jones and Menkveld where the rate of electronic messaging²⁷⁸ was positively correlated with narrower price spreads²⁷⁹, that the high rate of messaging allows HFTs to update their orders more quickly leading to improved liquidity.²⁸⁰

What should the SEC make of this? The high rate at which HFTs can submit, cancel and process quotes is positively associated with passive liquidity provision. At the same time, the high rate quote submission can stymie less technically proficient traders (the withdrawal of some firms from the market place during the Flash Crash). Thus in and of itself, the speed and number of quotes that HFTs can submit is not a cause of them becoming aggressive. The SEC is then faced with a tradeoff, a restriction on the number of quotes that a trader can submit to the market may aid other participants in times of Flash-Crash like event, but it would also seemingly inhibit the ability for HFTs to function. The criterion for judging market regulations this set out for this paper is the notion of promoting passive liquidity provision by HFTs and/or the limiting of the potential for aggressive behavior. A restriction on the number of quotes that can be submitted to an exchange would seemingly harm passive HFT behavior generally, so for the purposes of providing for market stability and efficiency, the notion

²⁷⁷ Clark.

²⁷⁸ The difference between “quote” and “electronic message” here is just semantic. The electronic messages examined by Hendershott, Jones and Menkveld contain quotes on price, volume, depth and other information relevant to HFTs finding a counterparty for a trade, all of which qualifies as an “order”.

²⁷⁹ Hendershott, Jones and Menkveld, 39.

²⁸⁰ Ibid. 28, 30-31.

of the limits on the number of orders that can be posted would most likely be more detrimental than helpful.

4.4.3 Order Submission Restrictions: Limit-Down/Limit-Up Restrictions

The final set of proposals in this section is a limit on the submission of orders based upon a price range.²⁸¹ This system would function in a similar capacity as the circuit-breakers already established²⁸²: orders outside of a given range would be immediately cancelled by the exchange itself, before ever allowing them to be fully submitted; the intent of this is the same, to avoid volatile shifts in prices by limiting the range in which trades can occur.²⁸³ “The limit-up/limit-down” mechanism, established jointly by the exchanges and FINRA, prevents trades in individual listed equity securities from occurring outside of a specified price band, which would be set at a percentage level above and below the average price of the security over the immediately preceding five-minute period.”²⁸⁴ This sort of restriction would be superior to the circuit-breakers (Section 6. Supplementary: The Initial SEC Response to the Flash Crash) as it would allow orders to be submitted without triggering a trading halt.²⁸⁵ For the purposes of this paper, analysis of this proposal will be limited to the general intent, rather than any specific regulatory policies as those will vary from venue to venue.²⁸⁶

At an initial examination, this framework would seemingly be a highly applicable method for dealing with a Flash-Crash like event. A limit on the range in which orders could be processed would have prevented a significant amount of the volatility

²⁸¹ Gould, 316-317.

²⁸² See Appendix 1.

²⁸³ Ibid. 317.

²⁸⁴ Security Exchange Commission, “SEC Approves Proposals to Address Extraordinary Volatility in Individual Stocks and Broader Stock Market”, from: <http://www.sec.gov/News/PressRelease/Detail/PressRelease/1365171482422#.UkfxNBbn8s>, (Accessed

²⁸⁵ The SEC began moving to replace the circuit breaker system with a more comprehensive system based upon the limit up/down system. – *ibid*

²⁸⁶ “...all trading centers, including exchanges, automated trading venues, and broker-dealers executing trades internally, must establish policies and procedures to prevent trades from occurring outside the applicable price bands...” – *ibid*.

experienced during the crash. Based upon the average calculated over a five- minute window, the precipitous price decline that occurred on May 6th 2010 in less than a two minutes would certainly not have occurred. Nor would the initial sell off by the fundamental trader that triggered the Crash, a trade calculated to run at 9% below the market²⁸⁷, which is well outside the 5% threshold by the SEC.²⁸⁸ This system does not, however, address the liquidity crisis that occurred during the crash. If the participants decide to pull away from the market, the limits on trades become irrelevant and the price will fall anyway. The potential for out-of-limit trading and the necessity for such a system to cope with this eventuality was noted by Alyse Gould,²⁸⁹ which could conceivably cause some liquidity problems as viable orders would be cancelled.²⁹⁰ Liquidity drops when fewer numbers of buyers and sellers connect, and this systems cancels orders outside of the given range even if there is viable counterparties on both sides.

This type of order submission restriction should, from the literature reviewed in section 3, not significantly affect HFT behaviour for the worse. Hendershott and Riordan noted that that algorithmic traders, of which HFTs are now the significant variety, more often trade within the bid-ask spread than outside of it.²⁹¹ These trades, by definition, would almost always be within the range set by this restriction. In the case of the Flash-Crash, when HFTs were rapidly shifting “toxic” volume in the face of evaporated liquidity (thereby eventually competing to the point of becoming aggressive an consuming liquidity)²⁹², HFT behaviour would have been significantly curtailed, alleviating some of the liquidity crisis.

²⁸⁷ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 2.

²⁸⁸ Security Exchange Commission, “SEC Approves Proposals to Address Extraordinary Volatility in Individual Stocks and Broader Stock Market”

²⁸⁹ “...legitimate trades that begin to pass outside these limits... would be blocked, which would inhibit the market from making profitable moves. If the SEC’s ultimate goal is to stabilize the equity market while bolstering the economy, then this problem would need to be solved proactively... if there is no way that prices could legitimately very beyond the limits, security value could be harmed” - Gould, 319

²⁹⁰ Chordia, Roll and Subrahmanyam, 14.

²⁹¹ Hendershott and Riordan, 18.

²⁹² U.S. Commodity Futures Trading Commission and Security Exchange Commission, 3, 14-15.

4.5 Financial Transaction Tax

The final proposal, that of a Financial Transaction Tax (FTT), calls for the exaction of a small fee of 3 basis points on any financial transaction over \$100 in value on the exchanges.²⁹³ As noted above, HFTs often trade within seconds or milliseconds based upon minimal price differences between the bid- and ask- spreads. This sort of tax would virtually eliminate those trades as a profitable strategy for HFTs, the net result basically being to “slow down” the market.²⁹⁴ This is perhaps the most severe of the regulations, as it would almost destroy the ability for HFTs to function. The benefit of this in the case of the Flash Crash is very clear, slower markets would have precluded the sudden and drastic price changes that occurred after the large sell off which triggered the crash. Consider the “hot potato” effect that occurred at 2:45 p.m. May 6th, where HFTs rapidly transferred contracts on the sell-side only driving prices to plummet. The FTT would almost certainly have prevented these, as HFTs would not have attempted to trade on margin. The market still would have trouble absorbing the initial large sell off, but two of the sources of liquidity consumption, the hot potato effect and resulting pull back of the broader market due to data integrity concerns, would not have occurred. This clearly satisfies the first portion of the evaluation schema, preventing HFT aggression. However, such a tax completely fails the second portion of the schema, as it likely destroys HFT as a trading strategy.²⁹⁵ As noted above the intent is to “slow down” the markets, which would severely inhibit the ability for HFTs to engage in passive liquidity provision. Just as it would serve to control HFTs during a Flash-Crash-like event, the effects would also apply to general HFT behaviour. Consider Section 3.1 of this paper where HFTs were found to positively impact the market, the FTT would inhibit

²⁹³ Office of Senator Tom Harkin, Press Release.

²⁹⁴ Mark Rosenman

²⁹⁵ A similar tax has been proposed across within the European markets, one of the expected goals being to eliminate high-frequency trading. – Ernst & Young, Tax Policy Services “Financial Transaction Tax: Which Way Now?” (April 2012), from: [http://www.ey.com/Publication/vwLUAssets/Financial_Transaction_Tax_implications_for_banks/\\$FILE/FTT_flyer_01.pdf](http://www.ey.com/Publication/vwLUAssets/Financial_Transaction_Tax_implications_for_banks/$FILE/FTT_flyer_01.pdf) (Accessed October 8 2013).

each of these effects. Thus the Financial Transaction Tax fails the second portion of the evaluation schema.²⁹⁶

4.6 Summary of Section 4

Forced to move ahead with regulating HFTs, the SEC faces an information problem: the sparse literature on the subject leaves little to work with. This section attempts to show how the passive-aggressive schema born out of the literature review in Section 3 can aid policy makers in choosing a regulatory framework. The notion that HFTs generally have a positive effect on market quality (Section 3.1) but can turn to liquidity consumers under certain circumstances (3.2 and 3.3) is combined with the stated objectives of the SEC to form an evaluation schema. The claim put forward in this section is that the SEC should select regulations that with the objective of limiting or preventing aggressive (liquidity consuming) behaviour without harming or impeding the ability for HFTs to function in a passive (liquidity providing) manner.

In terms of regulatory proposals, the “Limit Down-Limit Up” order submission restriction would best satisfy this schema. In the case of HFT aggression and a Flash-Crash-like event, these restrictions would limit the ability for HFTs to exacerbate negative market movements by restricting orders that could move prices excessively. This sort of regulation would also satisfy the second portion, given that HFTs already typically function as market makers and are more likely to trade within the posted bid-ask spread, such a restriction would not impede these trading behaviours. As noted above, intervention into markets can sometimes have serious distorting effects (government failure), the “Limit-Down-Limit-Up” system, out of the proposals examined here, seems to have lowest chance causing a market distortion and hence, government failure. In conclusion, this is the regulatory option the SEC should pursue.

²⁹⁶ It should be noted that the tax could be implemented at a lower level than the 3 basis points per \$100 transaction. Such a consideration, however, does not seem to indicate that the FTT might become more amenable to the evaluation schema of this paper. As noted above, HFTs derive profit from small, short term price deviations, that often do not exceed a few cents per share. Any tax on trades such as these would impede HFTs from deriving profit from them and would still serve as a impediment to passive liquidity provision.

The two other order submission restrictions fail to satisfy this schema. A minimum post time (“slowing down”) the markets would limit the ability of HFTs to aggressively consume liquidity but it would also impede passivity by limiting the ability of HFTs to act passively by limiting their exposure to the market. The same failure can be seen in restrictions on the number of orders that can be placed in a given period. Forcing HFTs to register as market makers, would satisfy the first portion of the schema, limiting the potential negative effects of HFTs. The method by which this could be implemented (restrictions based upon use of co-location services) seems unlikely to satisfy second portion by likely forcing HFTs away from the exchanges. Incentives for HFT passivity fail in the other direction, only aiding in HFT passivity and doing virtually nothing to limit or stop aggression. Finally, the Financial Transaction Tax, while effective in impeding HFT aggression, harms the market by effectively eliminating high-frequency trading, and thus, HFT passivity.

There are some significant limitations²⁹⁷ of this analysis that deserve to be mentioned here. First, the argument that order restrictions based upon price range are the best regulatory option stems from the evaluation schema. If this schema is flawed (a fact that can either be established or rejected by further research into the effects of high-frequency trading) than the recommendation made here is either faulty or unwarranted. Secondly, there is no certainty on this issue in terms of costs and benefits of each regulatory option. Finally, all of these options fail to address the use, proliferation and effects on the market from dark pools. While their effects are not yet fully understood, no regulatory steps should be taken without making considerations on the use of dark pools. As far the policy recommendation made in this paper (the Limit-Up/Limit-Down Order Submission Restrictions), there is no direct implications for the use of dark pools except in that not impeding passive HFT behaviour *should* keep a level of incentive for high-frequency traders on the established exchanges. In conclusion, out of the options and literature reviewed here, the Limit-Up/Limit-Down system seems to be the best regulatory option. However, this should be understood within the limitations discussed above.

²⁹⁷ All of the limitations discussed here could be eliminated or better understood with further research into high-frequency trading, and more generally, the effects of technology on the markets.

5. Conclusion

High-frequency trading represents a novel evolution in trading strategies and the equities markets, and as with any new technology this means benefits as well as perils. For regulators at the SEC, its unfamiliarity presents a problem in terms of policy options. This paper is intended to fill some of the void in knowledge about high-frequency trading and possible regulations. The literature reviewed in Section 3 demonstrated that HFTs can have both positive (Section 3.1) and potential negative (Sections 3.2 and 3.3) effects on the market place. This dichotomy was used to better adapt the findings of the literature to the purpose of SEC regulation (“...(T)o protect investors, maintain fair, orderly and efficient markets and facilitate capital formation.”²⁹⁸). Hence the creation and utilization of the evaluation schema: Any efforts taken by the SEC in relation to regulating high-frequency trading should be done with (1) the objective of limiting or preventing aggressive (liquidity consuming) behaviour without (2) harming or impeding the ability for HFTs to function in a passive (liquidity providing) manner. The importance of this schema is paramount if regulators wish to be both effective and minimize the chance for government failure at the same time.

When this schema was applied to the regulatory proposals discussed in 4.1 order restriction submissions based upon price range, namely the Limit-Down/Limit-Up (Section 4.3.3) system best fit this schema. It provides the ability to inhibit aggressive HFT behaviour without unduly hampering the ability of HFTs to act passively towards the market place. Each of the other proposals examined failed to satisfy both conditions of the schema. Given this, if the SEC in their quest to promote orderly and efficient markets wishes to attempt to maintain the positive benefits of HFTs while providing a limitation on HFTs becoming aggressive liquidity consumers, the recommendation of this paper is for the SEC to utilize the Limit-Down/Limit Up system.

²⁹⁸ Securities and Exchange Commission “The Investor’s Advocate: How the SEC Protects Investors, Maintains Market Integrity and Facilitates Capital Formation”.

In a broader sense this paper should encourage regulators to form a nuanced view of a new trading phenomena. Simply looking at the Flash-Crash (Section 2.2) and then considering what sort of regulations would prevent such another occurrence in the future would lead a policy maker to consider any one of the proposals noted in Table 1 as viable. If the objective is simply to prevent another May 6th 2010, than any of these would work. However, this one sided analysis would ignore the positive benefits that HFTs can have. The overall purpose of this paper is to demonstrate that the SEC can and should take a more nuanced approach to dealing with the issues surrounding high-frequency trading.

The analysis presented in this paper is not without some problems that should be mentioned. Firstly, there is a methodological concern, drawing conclusions solely from the Flash-Crash on the negative consequences of high-frequency trading leaves a considerable amount of uncertainty. Unfortunately, there are no other market events with similar structure, participants and outcomes to compare the Flash Crash to. In this sense, May 6th 2010 is both a member of a category of Crashes and the category itself.²⁹⁹ It would be in error not to note that a significant number of the conclusions drawn in this paper are the result of analysis of what appears to be a Black-Swan event. If another such Crash comes along but demonstrates a different role and negative effect of high-frequency trading, than this project would likely require serious revision. This sort of criticism can also be applied to the notion of concluding that, generally, HFTs have a positive effect on the market. More inquiry into the benefits noted in Section 3.1 is required to strengthen this claim. General research into the effects of high-frequency trading would seriously aid in providing more detail to any analytical project such as this. One key area of research should be an analysis of the effects of high-frequency trading on commodity futures markets. As noted at the beginning of Section 4, the Commodity Futures Trading Commission is considering regulations similar to those by the SEC. More research should be conducted to determine whether or not the CFTC faces divergent issues on the matter of regulation versus the SEC, and if the evaluation schema used in this paper is appropriate for the case of the CFTC.

²⁹⁹ As of the time of writing of this paper.

In terms of strengthening our understanding of the role of regulation and the effects of high-frequency trading, comparisons should be made with the microstructure and regulation between the U.S. and European markets. This sort of research would also serve to enlighten the policy recommendation made in this paper. Also, as noted in Sections 3.2 and 3.3, the same technological innovations that have led to high-frequency trading have also led to the development of dark pools. Further research into dark pools, their effects on the market, and the possibility of regulatory steps in this arena.

Earlier, this paper asked the question how does a policy maker such as the SEC regulate something they don't fully understand? The answer would seem to be, very carefully. The route taken in this paper was simple and linear, a review of literature of the effects of high-frequency trading, which rather than forming competing paradigms where authors contradict one another a progressive relationship was found: the positive, cautionary and critical viewpoints. Even with the sparse literature available, this paper was able to demonstrate that enough inferences can be made from general academic research into HFTs to inform a schema for evaluating regulatory proposals. Further research would almost certainly refine this schema allowing for greater explanatory and predictive power.

Overall, the rise of high-frequency trading proves to be an interesting problem for regulators and academics. The regulator who is obligated to move forward and attempt to work to resolving a problem must utilize the information available. This paper attempts to aid the regulator in this process, providing a schema of passive vs. aggressive understanding of HFT behaviour and demonstrating the how it can be used, ultimately indicating a policy course that should have multiple benefits with the least negative consequences.

6. Supplementary: The Initial SEC Response to the Flash Crash

In response to the Flash-Crash, the Security Exchange Commission and the Commodities Futures Trading Commission put forward four main regulatory changes: (1) improved circuit breakers, (2) restrictions on “erroneous trades”, (3) the banning of “stub quotes” and (4) a consolidated audit trail system.³⁰⁰ The changes to the system of circuit breakers was intended to prevent a sharp market movement like that observed during the Flash-Crash, by halting trading when a dramatic price change occurs. The premise of this is quite clear, a halt to trading would aid in the market being able to gauge the appropriate response allowing the broader marketplace to be alerted to a potential problem and act accordingly³⁰¹: “pausing a market can be an effective way of providing time for market participants to reassess their strategies, for algorithms to reset their parameters, and for an orderly market to be re-established.”³⁰² For a given stock or security, a 15- minute hold is implemented if a trade occurs outside of a specific price “band” (percentage level) from the averaged price occurring over the past 5 minutes.³⁰³ At the market level, circuit breakers have been introduced that would halt market trading if a single day decrease of over 7% is experienced.³⁰⁴ The intent of both of these systems is to forestall any further movement to allow for the market accommodate more

³⁰⁰ Gomber et. al., 45.

³⁰¹ Bidisha Chakrabarty, Shane A. Corwin and Marios A. Panayides, “When a Halt is Not a Halt: An Analysis of off-NYSE Trading during NYSE Market Closures”, from: *Journal of Financial Intermediation* (20, 2011), 362; Gould, 311-312, 315.

³⁰² U.S. Commodity Futures Trading Commission and Security Exchange Commission, 6.

³⁰³ Security Exchange Commission, “Investor Bulletin: New Measures to Address Market Volatility”, <http://www.sec.gov/investor/alerts/circuitbreakersbulletin.htm> (Accessed February 7th, 2013)

³⁰⁴ Ibid.

fundamental price movements that may be disguised by erroneous trades or momentary gaps in liquidity.³⁰⁵

An erroneous trade is one that occurs at a price that has a substantial deviation from the current market price due to either computer malfunctions or human error.³⁰⁶ At the time of Flash Crash, many traders were uncertain which trades would stand and which were to be cancelled by the exchanges as erroneous (a situation that revealed many of the decisions by regulators to be arbitrary).³⁰⁷ Under the new regulatory framework, trades occurring 20% - 30% away from the reference price (once again defined as the average of a given stock or security over the previous 5 minutes) would be cancelled by the exchange.³⁰⁸ This should limit volatility in price movement by preventing any trades that should have only be submitted in error, preventing a 'panic'-like situation caused by excessive price movements. A similar principle exists behind the decision to ban stub quotes. These were used by firms when they didn't want to trade at certain prices and wished to pull away to ensure no trades occur, a trading mechanism traditionally used by market makers to maintain their obligations during a shortage of liquidity.³⁰⁹ In order to achieve this "pull away" effect, these quotes were often irrationally high or low, from one penny to \$100,000.³¹⁰ Instead market makers are now required to keep posted quotes within a given percentage of the national-best-bid-and-offer.³¹¹

³⁰⁵ Security Exchange Commission, "National Market System Plan – Market Volatility" (May 31, 2012). <http://www.sec.gov/rules/sro/nms/2012/34-67091.pdf> (Accessed September 10th, 2013), 9.

³⁰⁶ Investopedia, "Erroneous Trade", <http://www.investopedia.com/terms/e/erroneous-trade.asp> (Accessed March 10th, 2013)

³⁰⁷ Barrales, 1236-1237.

³⁰⁸ Security Exchange Commission, "SEC to Publish for Public Comment Proposed Rules for Clearly Erroneous Trades", <http://www.sec.gov/news/press/2010/2010-104.htm> (Accessed March 10, 2013)

³⁰⁹ Investopedia, "Stub Quote", <http://www.investopedia.com/terms/s/stub-quote.asp> (Accessed March 10, 2013)

³¹⁰ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 5.

³¹¹ Security Exchange Commission, "SEC Approves New Rules Prohibiting Market Maker Stub Quotes" <http://www.sec.gov/news/press/2010/2010-216.htm> (Accessed March 10, 2013)

Finally, the SEC implemented a market-wide “consolidated audit trail system” in order to aid regulators in monitoring and analyzing trading activity.³¹² Acknowledging that automation in the markets has dramatically increased the amount of data available to regulators³¹³, the SEC launched a program to streamline the record keeping of order submissions, cancellations and modifications across the various exchanges.³¹⁴ This system is intended to enhance regulators’ ability to oversee the market by providing a “prompt and accurate” recording of all market transactions,³¹⁵ hopefully allowing for a more reactive regulatory set up: “ ...[The] consolidated audit trail will significantly improve the ability of regulators to reconstruct broad-based market events in an accurate and timely manner. The sooner regulators can reconstruct the event, the sooner we can inform the public and determine what, if any, responses might be required.”³¹⁶

The initial system of circuit breakers implemented were designed to provide a halt to trades where prices rose or fell by over 10% over a five-minute window.³¹⁷ As noted by Barrales, these were ineffective as the only times such a halt was implemented on the market, the trades that ‘tripped’ the breaker were cancelled as erroneously anyway.³¹⁸ In the case of the Flash Crash, the large sell-off that triggered the crash was

³¹² Security Exchange Commission, Press Release: “SEC Approves New Rule Requiring Consolidating Audit Trail to Monitor and Analyze Trading Activity”, July 11, 2012, <http://www.sec.gov/News/PressRelease/Detail/PressRelease/1365171483188#.UkAGfhbjn8s> (Accessed March 10, 2013)

³¹³ Security Exchange Commission, “Consolidated Audit Trail” (Rule 613, October 1, 2012), <http://www.sec.gov/rules/final/2012/34-67457.pdf> (Accessed March 10, 2013), 6.

³¹⁴ Mary L. Schapiro, “Opening Statement and SEC Open Meeting: Consolidated Audit Trail” (Speech to the U.S. Securities and Exchange Commission, July 11, 2012), <http://www.sec.gov/News/Speech/Detail/Speech/1365171490774#.UkCeXhbjn8s> (Accessed March 10, 2013), 19.

³¹⁵ Security Exchange Commission, “Consolidated Audit Trail”

³¹⁶ Schapiro, “Opening Statement and SEC Open Meeting: Consolidated Audit Trail”

³¹⁷ Gould, 302.

³¹⁸ Barrales, 1237; Ann L. Vlcek, “Comments To Ms. Elizabeth M. Murphy, Secretary, Security Exchange Commission”, Securities Industry and Financial Market Association, July 26, 2010., <http://www.sec.gov/comments/sr-bats-2010-016/bats2010016-8.pdf> (accessed September 20, 2013).

a deviation of only 9%³¹⁹, which would have not triggered a market halt.³²⁰ The current framework for these circuit breakers call for trading halts to occur when a trade is executed outside a specific price band (7%, 13% and 20% depending on the stock or security in question.)³²¹ This system seemingly flawed in the same manner as the earlier version, if an initial trade of a 9% deviation can set off a Flash Crash, the 13% and 20% price bands would be quite ineffective. There is also some concern that the system of circuit breakers may actually exacerbate volatility by causing a disruption to the market, causing traders to over-react thereby furthering price swings.³²² This occurs as investors become weary of trading a security that has been halted, essentially a signal of a “red flag” indicating a problem.³²³ Of a lesser note, there is also concern that this system may halt legitimate trades (those that adequately can be absorbed by the market), but are poorly planned and executed.³²⁴

In the case of the market wide circuit breakers where trading is halted if the exchange drops over a certain percentage from the closing average of the previous day³²⁵, the drop seen on May 6th clearly would have triggered a halt. The problem with this is what does this system actually do to market quality? While there is a strong case

³¹⁹ “This large fundamental trader chose to execute this sell program via an automated execution algorithm (“Sell Algorithm”) that was programmed to feed orders into the June 2010 E-Mini market to target an execution rate set to 9% of the trading volume calculated over the previous minute, but without regard to price or time.” - U.S. Commodity Futures Trading Commission and Security Exchange Commission, 2.

³²⁰ Brown, 216,

³²¹ Security Exchange Commission, “Investor Bulletin: New Measures to Address Market Volatility”,

³²² The risk that an order might be cancelled can discourage a trader from posting the order in the first place (even though there may be a viable counterparty) thus discouraging liquidity provision, David, G Cushing, “Re: File No. 57-02-10 (Comments on the Proposed 5RO Rules Regarding Amendments to Clearly Erroneous Rules and Pilot Program Regarding Circuit Breakers)”, July 19th, 2010, <http://www.sec.gov/comments/sr-bats-2010-016/bats2010016-2.pdf> (accessed September 14th, 2013), 3.; Gould, 313.

³²³ David M. Serritella, “High Speed Trading Begets High Speed Regulations: SEC Response to Flash Crash, Rash” from *University of Illinois Journal of Law, Technology & Policy* (2010:2), 441.

³²⁴ Gould 312.

³²⁵ See: NYSE Information Memo 11-31 “New Rule 80B Circuit Breaker Levels for First Quarter 2012”, http://www.nyse.com/nysenotices/nyse/rule-changes/detail;jsessionid=4B6FAB7FFBB1AC582F7915525AE68D7F?memo_id=11-31 (accessed September 14, 2013)

to be made for the benefits of such halts, specifically in cases of price declines "... [are] especially prone to feedback effects whereby selling, if left unchecked, can beget further selling in a vicious cycle."³²⁶ But in the case of the Flash Crash, this halt certainly would have delayed (or might have prevented) the rally that occurred only a few minutes after the crash³²⁷. There are also several moral hazards here, notably that trading halts "...impose a substantial cost on market participants...[they] disrupt both liquidity and informationally-motivated trades. This in turn could actually reduce the informativeness of prices."³²⁸ Where the objective of this sort of system is to stem a selling frenzy and thus stabilize a the market system, circuit breakers carry the potential for disrupting the ability for market participants to understand what is happening in terms of market movements due to disruptions in trading. It is also important to note that the circuit breakers themselves only function on the market's ability to react in a rational and appropriate manner, not to actually deal with issues of excessive volatility³²⁹, such as that which was experienced prior to the Flash Crash.³³⁰

The volatility that occurred on May 6 2010 was certainly exacerbated by the triggering of the stub quotes submitted by market makers. During the Flash Crash, over 200,000 trades were executed at prices more than 60% away from their values immediately prior to the market collapse.³³¹ Instances where trades were executed at absurdly high or low prices³³² where clearly the result of these quotes that were never intended to be executed by the market makers who posted them.³³³ What is important to note here is that these quotes were only used to maintain obligations required as "market makers" and were never intended to be a viable trade, instead they were

³²⁶ Cushing, 2.

³²⁷ Barrales, 1245.

³²⁸ Chankrabarty et. al. 363.

³²⁹ Trading halts often are followed by periods of increased volatility and volume: See Charles M. C. Lee, Mark J. Ready and Paul J. Seguin, "Volume, Volatility and New York Stock Exchange Trading Halts", from *The Journal of Finance*, (49:1, March 1994).

³³⁰ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 9.

³³¹ *Ibid.*, 65.

³³² Madhavan, 20.

³³³ U.S. Commodity Futures Trading Commission and Security Exchange Commission, 5.

triggered when market liquidity had already evaporated.³³⁴ The causal implications here are while these quotes were a source of added volatility, they were not the primary cause of the crash. The initial drop in market liquidity was caused by a massive sell off by a long-term value investor, where the sell-orders overran the buy-side (order imbalance).³³⁵ As the prices kept falling precipitously, the liquidity shortage began to trigger the stub-quotes. This means while the ban on stub quotes conceivably lowers volatility in times of crises such as the Flash-Crash, it would not prevent or ameliorate the effects in the drop in liquidity in the first place, nor would it deal with the problems of order imbalance and toxicity.

The other two regulatory changes made by the SEC are very likely even less effective in the case of another Flash Crash. As noted above, the changes made relating to the rules for eliminating erroneous trades was merely a streamlining and simplification of rules that already existed. On the matter of the audit-trail system, while it certainly would be useful in informing regulators on market events after-the-fact, allowing the SEC to more carefully tailor regulation³³⁶, it would be of little use during a Flash-Crash-like event. Given the speed of the decline and the number of orders that are processed, it would almost certainly take longer to piece together the market event than the length of the actual event itself. Overall the SEC's response should be met with a mixed reaction. Some of the changes made would almost certainly be beneficial in another Flash-Crash-like event, the combination of circuit breakers and stub quote elimination (if in place during May 6th) would have eliminated the worst of the volatility.³³⁷ This, however does not address the initial decline in liquidity, the cause of the crash itself.³³⁸

³³⁴ Ibid., 38.

³³⁵ Kirilenko et. al., 9, 36; Barrales, 1232.

³³⁶ Gould, 324.

³³⁷ Barrales 1244.

³³⁸ Gould, 315.

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