High Frequency Trading

Post-Flash Crash Studies Matrix[1]

April 2013

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Author	Positions/Key Points	Link
White Papers / Studies		
High-Frequency Trading Behaviour and its Impact on Market Quality: Evidence from the UK Equity Market (Bank of England Working Paper No. 469, 2012)	• Paper analyzes the intraday behavior of high-frequency traders (HFTs) and its impact on aspects of market quality such as liquidity, price discovery and excess volatility. • Paper finds that HFTs differ significantly from each other in terms of liquidity provision: while some HFTs mostly consume liquidity (i.e. trade more 'aggressively') by primarily executing trades via market orders, others mostly supply liquidity (i.e. trade more 'passively') by primarily executing trades via limit orders. • Paper further explores the relationship between HFT activity and market quality. The paper notes that volatility can be either "good" (when price changes reflect the arrival of new information about fundamentals) or "excessive" (when price changes do not reflect any information about fundamentals). • Paper find that both higher price volatility and lower spreads cause HFT activity to increase. The results show that there are instances where HFTs contribute (in absolute terms) a large amount of both "good" and "excessive" volatility; more so than the average, non-HFT, trader. Hence, given the instances of large contributions of both "good" and "excessive" volatility by HFTs, it is not immediately clear what the welfare implications of HFT activity are.	Study
The Trading Profits of High Frequency Traders (Baron, Brogaard, Kirilenko, 2012)	• Paper finds that HFT is highly profitable (before incorporating operating and trading costs) but not without risks. The magnitude and consistency of their profits as well as their risk-return tradeoff demonstrate unusually strong performance. • Further, HFTs are a heterogeneous set of firms that have different trading and profit characteristics. • Lastly, the paper describes different market conditions and firm characteristics that are associated with profitability, such as aggressiveness, speed, and newness.	Study
Equilibrium High Frequency Trading (Biais, Foucault, Moinas, 2011)	• Paper finds that High Frequency Trading (HFT) enables investors to seize trading opportunities, which raises gains from trade. • In addition, paper states that High Frequency traders can also process information on stock values before slow traders, which generates adverse selection.	Study

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High Frequency Trading (Biais, Woolley, 2011)	• Study finds HFT improves informational efficiency (to the extent that it brings prices of related assets in line). However, the question is raised if it results in information only getting impounded in prices for a few seconds or minutes. If that is the case, then the study states that HFT may not contribute significantly to making economic decisions more efficient. • Authors state that HFT has ambiguous consequences, since on the one hand it can help traders finding counterparties and realizing gains from trades, but on the other hand it can generate adverse selection problems, preventing the realization of gains from trades. Therefore, in this context, the level of algorithmic trading that maximizes trading volume is not identical to the level that maximizes utilitarian welfare. • Absent a systemic crisis caused by HFT, HFT firms will also continue to develop increasingly sophisticated and rapid trading algorithms. These evolutions may, in the end, benefit markets and investors as a whole, by improving price discovery and liquidity. • Authors believe however, slow investors will therefore need protection from HFTs, with the buy-side will building their own trading algorithms (resulting in an arms race); or in the alternative, investors will increasingly rely on dark pools to avoid HFT algos. • The authors also argue that a systemic crisis related to HFT may result, either from operational risk (i.e. hardware failure) or correlated strategies leading to a downward price spiral. • Authors advocate suggest various regulator solutions, from circuit breakers to taxing HFT.	Study

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Financial Stability and Computer Based Trading (BIS: Paper 1, 2011)	• Economic research thus far provides no direct evidence that high frequency computer based trading has increased volatility. • However, in specific circumstances, the authors state a key type of mechanism can lead to significant instability in financial markets with computer based trading (CBT): self-reinforcing feedback loops (the effect of a small change looping back on itself and triggering a bigger change, which again loops back and so on). The feedback loops can be driven by changes in market volume or volatility, by market news, and by delays in distributing reference data. • Authors put forth a second cause of potential instability: a process known as normalization of deviance, where unexpected and risky events come to be seen as ever more normal (e.g. extremely rapid crashes), until a disaster occurs. • Study indicates that HFT impacts the dynamics of the markets, specifically noting: (a) interactions are taking place at a pace where human intervention could not prevent them – an important speed limit has been breached; (b) given this, computer based (and therefore mechanical) trading is almost obligatory, with all of the system-wide uncertainties that this gives rise to; (c) that information asymmetries then become more acute (and indeed different in nature) than in the past; and (d) that the source of liquidity provision has changed, to computer based and high-frequency trading, which has implications for its robustness under stress.	[Study](#)
The Impact of Computer Trading on Liquidity, Price Efficiency / Discovery and Transaction Costs (BIS: Paper 2, 2011)	• Evidence suggests that computerized trading (whether in the guise of high frequency trading or algorithmic trading) has generally improved market quality. Liquidity, as measured by bid/ask spreads and other metrics, has improved over the last decade. During this period, transaction costs have also fallen for both retail and institutional traders. These liquidity and transaction cost effects have been particularly pronounced for large stocks. There is also evidence that market prices are more efficient, consistent with the hypothesis that computerized trading links markets and thereby facilitates price discovery. • Authors' note that while overall liquidity has improved, there appears to be greater potential for periodic illiquidity. • Authors' further state that the speed of trading as well as the interconnectedness of markets made possible by HFT can transmit disruptions almost instantaneously across markets. • New forms of manipulation, such as algorithms programmed to take advantage of other algorithms, can raise trading costs and move prices away from efficient levels. Increasing competition in the high frequency space should limit such effects, as would new regulations.	[Study](#)

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The Impact of Technology Developments (BIS: Paper 3, 2011)	- Study argues that the pace of development of technology innovations in the financial markets, and the speed of their adoption, will continue to increase in the future. - Study states that computing power will get cheaper; automated trading systems will get faster, and more intelligent. Further, the availability of cheap 'cloud' computing power means that computers can readily be used to evaluate vast numbers of alternative designs for trading strategies, selecting the best designs and further refining them. - Study notes that computer-designed and computer-optimized robot traders are likely to be increasingly viewed as routine, and in time could potentially come to replace current algorithms designed and refined by humans. - Further, in several significant markets (such as foreign exchange) the overall number of human traders engaged in on-the-spot execution of orders has fallen sharply in recent years, and is likely to continue to reduce in the future. - Authors' argue that the primary challenges for the future are centered on how the complex dynamical socio-technical ecosystem of the global financial markets can be mapped, managed, and modified to prevent undesirable behavior.	Study

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Electronic Trading and Market Structure (BIS, 2011)	• Study argues that entrant markets benefit from the presence of high-frequency traders and high-frequency traders thrive on the competition between markets; hence the authors' state there appears to be a symbiotic relationship between HFT and new market entry. • Study indicates that the migration to electronic trading coincided with a gradual decline in average transaction cost it also coincided with the occasional disappearance of liquidity supply. However, while transaction costs have declined, on average more frequent and more extreme spikes occur when migrating to electronic trading. • The presence of high-frequency traders in electronic markets improves welfare when they act as liquidity suppliers and thereby reduce the informational friction that exists between non-synchronously arriving investors. It, however, reduces welfare when HFTs picks off investors' quotes at superhuman speed on information that would have been revealed to investors at a somewhat lower frequency. • In addition to superior information processing capacity, a high-frequency trader also pays a market to co-locate its trading robot so as to operate as close as possible to the matching engine. Authors' note that such a privilege might or might not be good for the market as a whole. • Study puts forth that among high-frequency traders, speed might become the source of a socially wasteful arms race. If one HFT invests in hardware or software to be microseconds (one microsecond is one millionth of a second) faster to trade on a signal before a rival HFT can, nothing is necessarily gained in terms of social value. • Study also notes that high frequency electronic markets with low frequency system-wide monitoring increasingly allows for destructive doubling strategies.	Study

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High-Frequency Trading in the Foreign Exchange Market (BIS, 2011)	• The report represents the results of a fact-finding exercise conducted by a Study Group consisting of FX market experts from 14 Markets Committee member central banks. • The report provides that HFT has had a marked impact on the functioning of the FX market in ways that could be seen as beneficial in normal times. For instance, HFT helps to distribute liquidity across the decentralized market, improving efficiency, and has narrowed spreads. • However, the report notes that the introduction of HFT to the market has affected the ecology of the FX market in ways that are not yet fully understood. For instance, questions remain about HFT participants' willingness to provide liquidity on a sustained basis under different market conditions. • Report indicates that HFT may under some circumstances accelerate and propagate shocks initiated elsewhere (i.e. in regards to the May 6th, 2010 Flash Crash). • Hence, the report raises the key question if other market participants will be able to adapt to the presence of HFT; further, the question is posed how will the market environment be affected when those failing to keep up, change their trading behavior, or exit the market completely.	Study
Swedish Financial Supervisory Authority (2012)	• Study states that according to both current research on the subject and the views of Swedish actors on the financial market, the effects of high frequency and algorithmic trading are limited. • Overall, the study notes that there is an indication that certain aspects of liquidity have deteriorated and that the market has become more volatile, but these changes can also be explained by multiple factors and not merely the emergence of high frequency trading. • In general, study notes that Swedish actors are not overly concerned about the effects of high frequency trading. Rather, they have accepted that trading has undergone a transformation as a result of new legislation and technological developments. • Study provides that even if the effects on trading are considered to be limited, there is still considerable concern about market abuse. • Study states that existing research also indicates that the impact of high frequency trading on financial stability is still limited, however the risk of increased volatility is a possibility (however, HFT firms business models likely limit the risk for contagion).	Study

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International Evidence on Algorithmic Trading (Boehmer, Fong, Wu, 2012)	• The authors use a large sample from 2001 – 2009 that incorporates 39 exchanges and an average of 12,800 different common stocks to assess the effect of algorithmic trading (AT) intensity on liquidity in the equity market, short-term volatility, and the informational efficiency of stock prices. • The authors find that, on average, greater AT intensity improves liquidity and informational efficiency, but increases volatility • However, in contrast to the average effect, more AT reduces liquidity in small stocks; has little effect on the liquidity of low-priced or high volatility stocks; and leads to greater increases in volatility in these stocks. • Finally, during the days when market making is difficult, AT provides less liquidity	[Study](#)
High Frequency Trading and Price Discovery (Brogaard, Hendershott, Riordan, 2012)	• By using randomly selected stocks from the NYSE and NASDAQ (2008-2009), study finds that overall, HFT increases the efficiency of prices by trading in the direction of permanent price changes and in the opposite direction of transitory pricing errors. • Overall HFT has a beneficial role in the price discovery process in terms of information being impounded into prices and smaller pricing errors (however HFT's information is short-lived at less than 30 seconds). • The study's results provide no evidence that HFT contribute to market instability in prices. To the contrary HFT overall trades in the direction of reducing transitory pricing errors both on average days and on the most volatile days during a period of relative market turbulence (2008-2009).	[Study](#)
Yes, U.S. Stocks are Getting Riskier (Brown, Waller, 2012)	• Paper evaluates the short and long term volatility of equities from 1964-2009. • Paper finds at the firm level, there is a slight downward trend in the long-run base-line component of volatility. In contrast, the paper finds a substantial increase in the short-run instability component at the firm level. • Paper notes that there has been a dramatic increase in the tendency for risk characteristics of the typical firm to change substantially over fairly short horizons.	[Study](#)

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Trading Rules Over Fundamentals: A Stock Price Formula for High Frequency Trading, Bubbles and Crashes (Cadogan, 2012)	• Study presents a model that suggests that in periods of uncertainty, if volatility is above historic average, a relatively small short selling trade strategy is magnified exponentially, and the stock price plummets when such strategies are phased locked for a sufficient large number of traders. • Study states that extant regulatory proposals to control price dynamics of select stocks, i.e., pause rules such as "limit up/limit down" bands over 5-minute rolling windows, may mitigate but not stop future market crashes or price bubbles from manifesting in underlying indexes that exhibit HFT stock price dynamics.	[Study]
Where is the Value in High Frequency Trading? (Cartea, Penalva, 2012)	• Study analyzes the impact of high frequency (HF) trading in financial markets based on a model with three types of traders: liquidity traders (LTs), professional traders (PTs), and high frequency traders (HFTs). • The main findings of the study are: (1) the price impact of liquidity trades is higher in the presence of the HFTs and is increasing with the size of the trade. In particular, the study shows that HFTs reduce (increase) the prices that LTs receive when selling (buying) their equity holdings; (2) although PTs lose revenue in every trade intermediated by HFTs, they are compensated with a higher liquidity discount in the market price; (3) HF trading increases the microstructure noise of prices; and (4) the volume of trades increases as the HFTs intermediate trades between the LTs and PTs. • Stud provides that in equilibrium, HF trading and PTs coexist as competition drives down the profits for new HFTs while the presence of HFTs does not drive out traditional PTs. • Study further notes that HFTs distorts market conditions through prices, and by exacerbating price impact, the HFTs induce additional market impact costs on participants, especially the LT. • Study implies that overall, the effect of HFTs is to reduce the value of the stock market as a forum for providing a way for investors to convert their equity into cash (and vice-versa) quickly and at a reasonable price. This is due primarily to the adverse effect of HFTs on prices (costs of execution). This value reduction would, in a more general framework, be passed on to the firms raising capital in equity markets. • Hence, the study argues that as equity buyers recognize the increased trading execution costs from HFTs, they will require greater discounts from IPO issuers, resulting in greater IPO underpricing, especially for shares sold to large institutional investors.	[Study]

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Market Efficiency and Microstructure Evolution in U.S. Equity Markets: A High-Frequency Perspective (Castura, Litzenberger, Gorelick, Dwivedi, 2010)	• Study is based on the Russell 1000 and Russell 2000 (as of Q4-2009). • Paper provides some evidence that the U.S. equity markets appear to have become more efficient with tighter spreads, greater liquidity at the inside, and less mean reversion of mid-market quotes over the past several years; a period that has seen a sizable increase in the prevalence of HFT, and a period during which there has been coincident growth in automation and speed on many exchanges. • Evidence is presented which shows that exchanges which moved toward greater automation earlier saw earlier improvements in market efficiency metrics. • Report further states that as the ratio of HFT activity to total market activity has grown, there appears to be no evidence that short-term volatility, liquidity or spreads have risen for the bulk of market participants. Rather, the evidence suggests a sympathetic relationship between HFT and the health of the overall markets.	Study
Market Efficiency and Microstructure Evolution in U.S. Equity Markets: A High-Frequency Perspective (Castura, Litzenberger, Gorelick, Dwivedi, 2012 - Update)	• Research note updates the data set to include more recent periods through the end of 2011. • Despite the spikes in macro-volatility, the updated research demonstrates that overall market quality metrics did not degrade, and general trends seem to have remained stable, with decreasing quoted bid-ask spreads and stable or improving price efficiency metrics. • Available liquidity at the inside has shrunk somewhat over the past year but remains at historically high levels.	Study

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A Financial Transaction Tax – Review of Impact Assessments (City of London Economic Development)	• Transaction taxes do not address systemic risk and advise that systemic risk is better addressed by regulation already in train or under discussion. • The proposed EU FTT is an imprecise and ineffective tool for addressing HFT as it does not consistently differentiate HFT from other forms of trading and is based on a number of unsubstantiated economic and social assertions concerning the value of HFT. • Moreover, it is questionable whether speculation that is, rightly or wrongly, associated with HFT will be effectively addressed by the FTT. In fact, ISDA argues that the drop in liquidity (associated with the increase in transaction costs that a transaction tax will bring) will, in fact, create room for speculation. • An FTT motivated by HFT prevention presumes that HFT has no economic or social value when, in fact, there is no real consensus on the interaction between the FTT, drops in liquidity and consequential changes in volatility and price discovery, or the economic and social returns these interactions yield. • Finally, according to the CPB, it is unclear that HFT contributes to systemic risk or leverage.	[Study](#)
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 (CFTC / SEC Joint Report, 2010)	• Joint report by the CFTC / SEC to analyze and determine the cause of the May 6, 2010 "Flash Crash". • Report finds that under stressed market conditions, the automated execution of a large sell order can trigger extreme price movements, especially if the automated execution algorithm does not take prices into account. • In addition, the interaction between automated execution programs and algorithmic trading strategies can quickly erode liquidity and result in disorderly markets. • Report states that as the events of May 6 demonstrate, especially in times of significant volatility, high trading volume is not necessarily a reliable indicator of market liquidity. • Report noted that many market participants employ their own versions of a trading pause – either generally or in particular products – based on different combinations of market signals. While the withdrawal of a single participant may not significantly impact the entire market, a liquidity crisis can develop if many market participants withdraw at the same time. This, in turn, can lead to the breakdown of a fair and orderly price-discovery process, and in the extreme case trades can be executed at stub-quotes used by market makers to fulfill their continuous two-sided quoting obligations. • Lastly, the report put forth that the events of May 6th demonstrated that market participants' uncertainty about when trades will be broken can affect their trading strategies and willingness to provide liquidity.	[Study](#)

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Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market (Chaboud, Chiquoine, Hjamlmarsson, Vega, 2011).	• Paper analyzes the impact of the growth of algorithmic trading on the spot interdealer foreign exchange market. • Paper finds some evidence that algorithmic trading has a slight positive effect on market liquidity in the euro-dollar and dollar-yen market. • Further, no evidence is found to back the often-voiced concern that algorithmic trading leads to excessive volatility in any of the three currency pairs we analyze. • However, the study does not cover a truly tumultuous period in financial markets. Therefore, the authors are still uncertain about how algorithmic traders may behave in a crisis period.	Study
Controlling Risk in a Lightning-Speed Trading Environment (Chicago Fed Letter, Clark, 2010)	• Paper puts forth that there is evidence that high frequency algorithmic trading has some positive benefits for investors by narrowing spreads. • Paper notes that a major issue for regulators and policymakers is the extent to which high-frequency trading, unfiltered sponsored access, and co-location amplify risks, including systemic risk, by increasing the speed at which trading errors or fraudulent trades can occur. • Paper notes that firms with weak internal controls are exposed to risks related to the speed at which trades can be executed and the circumvention of pre-trade risk controls. Moreover, because black boxes sometimes trade with other black boxes, an erroneous price from one could impact the trading strategy of another. • Paper argues that it is of paramount importance is the speed at which clearing members receive post-trade information from the clearinghouse and incorporate this information into their risk-management systems so that erroneous trades can be detected and stopped	Study

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How Do Proprietary Trading Firms Control the Risks of High Speed Trading? (Chicago Fed, Clark, Ranjan, 2012)	• Study found that regardless of the risk management structure employed, not all trading firms risk platforms can calculate enterprise wide portfolio risk. In addition, no firm evenly applies every risk check to each trading strategy. Most firms apply fewer pre trade risk checks to some strategies to reduce latency. • A majority of the firms interviewed experienced out of control algorithms on one or more occasions, which may have been detected by the firms and/or the trading venue. A review of the circumstances that led to these out of control algorithms revealed that there is no clear pattern related to their cause. One firm's out of control algorithm resulted in a significant impact on market prices over a short time frame. • Study provides the main participants in the markets with suggestions on how to improve their risk management practices, including quality assurance of the code and development process, comprehensive audits of customers that access the markets directly, etc. • Study suggests that regulators focus on solutions rather than problems, and to provide guidelines on how trading firms should manage their risk.	Study
Algorithmic Trading and Market Dynamics (CME Group, 2010)	• Study assesses the degree to which algorithmic trading is correlated with market liquidity and volatility in the context of several flagship CME Group products including E-mini S&P 500, EuroFX, eurodollar, 10-Year Treasury and Crude Oil futures. • Study results suggest that, on balance, increased proportions of algorithmic trading sourced volume and message traffic tend to be associated with enhanced liquidity and reduced volatility.	Study

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Who Let The Bots Out? Market Quality in a High Frequency World (Credit Suisse, 2012)	• Measured daily volatility by calculating the average close-to-close price swing. Found that 2011 was actually only the sixth most volatile year since 1980. Study noted that while 2008 tops this list, 2002 and 2000, when electronic trading, and certainly high frequency trading were a very small part of the market, also rank above 2011. Extending further back to the 1930s, 2011 doesn't even crack the top 15 most-volatile years. • Study calculated price changes intraday and found that intraday vol has been steadily decreasing since 2005. • Study states that the offsetting buys and sells of HFT occur over microseconds, and therefore it is inconsistent that they could lean on a position in a single direction long enough to influence a stock's volatility. If anything, the matched buying and selling should dampen price oscillations. Long only investors do not all enter the market at the same time, so high frequency buying and selling can help to meet their liquidity needs whenever they may arise. • Study noted that spreads have tightened over time, in all volatility bands measured. • Study looked to determine if there is a increased risk of another flash crash and it found that the number of occurrences in which a "mini" flash crash (as defined as a 1% price gap within a 1 minute interval in the S&P 500) and found that the number of occurrences has been decreasing. • Study recognized the increased message traffic as a result of HFT. Study noted that while it may appear to be noise, it still contributes to buy and sell price indications to the lit markets.	Study

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High Frequency Trading – The Good, The Bad, and The Regulation (Credit Suisse, 2012)	• Study groups HFT strategies to examine their effects in more detail. On the one end of the spectrum, market making and statistical arbitrage strategies profit by reacting to – and correcting – short term mispricing, thereby improving market quality. In contrast, other strategies such as quote stuffing, latency arbitrage and momentum ignition seek to create short term mispricing and subsequently profit from it • A one-size-fits-all prescription for HFT may rein in some bad behavior, but it risks undoing the benefits of benevolent practices that happen to operate at high speed. However, the study states that the positive effects of market making and arbitrage style models may mask the more negative effects of other types of HFT strategies. • Not all HFT strategies are created equal, and some – such as market making – can have positive effects and provide additional liquidity. Study further states that Index (or ADR) arbitrage strategies keep prices efficient by ensuring that any mispricing across instruments is corrected quickly. High frequency traders sell when securities are overpriced (and buy when they are underpriced) relative to the index, helping to stabilize the market. Similarly, statistical arbitrage models that kick off when prices spike or volume temporarily dries up can help provide additional liquidity and reduce intraday volatility. • Study states that certain strategies seek to distort the playing field, such as quote stuffing, layering, order book, fade. It is noted that market manipulation in any form - whether high or low frequency - is already forbidden. Also, momentum ignition (creating "false" volume to force percentage of volume orders to trade) carries significant risk, as the size and timing of other market participants' trades can never be precisely known. Nonetheless, study finds evidence of this behavior on a daily basis. • Further, it is noted that "Quote stuffing" has become a common occurrence. It involves sending large numbers of orders and cancellations in rapid succession. This behavior may be designed to slow down market data; try to game the bid or ask to trigger other market participants' reactions in ways can subsequently be taken advantage of; or enable other forms of latency arbitrage, which may use other participants' slower connections (or market data) to exploit "stale" prices that the HFT participant knows are no longer accurate. • Study also assesses the variety of current and potential regulatory responses. Some measures – like order-to-trade ratios – are thoughtful and targeted, and most likely improve market quality if formulated correctly. Others, however, seem prone to unintended consequences, especially where their scope is broad.	[Study](#)

Author	Positions/Key Points	Link
High Frequency Trading – Measurement, Detection and Response (Credit Suisse, 2012)	• Study highlights a subset of negative high frequency trading, examining strategies such as: Quote Stuffing, Layering/Order Book Fade and Momentum Ignition. • Study states that although the majority of quote stuffing events only last a short period of time, they can have a significant impact. For instance, the study finds that average spreads and volatilities are higher in the immediate aftermath of these events. • Study provides that layering (the process of placing sell orders to give false impression of strong selling pressure to drive the price down and then the trader buys at a cheaper price) is more viable for high frequency traders. Their speed allows them to mitigate the risk of someone trading against those "false" orders by cancelling immediately in response to any upward moves. This means the buyer gets less than what was displayed on the screen – a common complaint of clients. • In addition, the study discusses momentum ignition, which is a strategy that attempts to trigger a number of other participants to trade quickly and cause a rapid price move.	[Study](#)
High Frequency Traders and Asset Prices (Cvitanic, Kirilenko, 2010)	• Study models the impact of a high frequency trader in an electronic limit order market populated by low frequency traders. • Study finds that the presence of a machine is likely to change the average transaction price, even in the absence of new information. • Study finds that in a market with a high frequency trader, the distribution of transaction prices has more mass around the center and thinner far tails. • Further, with a high frequency trading, the mean intertrade duration decreases in proportion to the increase in the ratio of the human order arrival rates with and without the presence of the machine; trading volume goes up by the same rate. • Study also find that a machine that optimizes expected profits subject to an inventory constraint submits orders that are essentially symmetric around the mean value of the human orders. The distance between the machine's bid and ask prices increases with its concern about the size of the remaining inventory. The expected profit of an optimizing machine increases in both the variance and the arrival frequency of human orders.	[Study](#)

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The Dark Side of Trading (Dichev, Huang, Zhou, 2012)	• Study investigates the effect of high volumes of trading on stock volatility. • Study finds economically substantial evidence that, controlling for fundamentals, more intensive stock trading is accompanied by increased return volatility. • Study does provide that the relation is weak to non-existent at low to moderate levels of trading but becomes increasingly strong as volume of trading increases. • As a result, the study puts forth that high volumes of trading can be destabilizing, injecting a sizable layer of trading-induced volatility over and above the unavoidable fundamentals-based volatility.	Study
High Frequency Trading – Better than its Reputation? (Deutsche Bank Research, 2011)	• Paper notes that existing evidence related to the impact of high-frequency trading on certain market quality and efficiency indicators is, as of now, inconclusive: while high-frequency traders provide liquidity to the market and contribute to the price formation process, some market participants feel themselves to be at a disadvantage by being unable to keep up with the necessary investments in trading technology.	Study
The Microstructure of the 'Flash Crash': Flow Toxicity, Liquidity Crashes and the Probability of Informed Trading (Easley, Lopez de Prado, O'Hara, 2011).	• Paper suggests that the 'Flash Crash' is better understood as a liquidity event arising from structural features of the new high frequency world of trading. • In the world of High Frequency trading, liquidity provision is dominated by computerized market makers programmed to place buy and sell orders while avoiding taking significant inventory positions. • Paper finds that when order flow toxicity increases, such market makers face significant losses and curtail their risks by reducing, or even liquidating, their positions. The consequent market illiquidity can then have disastrous repercussions for market participants. • Rather than advocating that HFT be banned, the authors propose potential solution that would potentially allow high frequency market makers to remain in the marketplace providing liquidity, therefore mitigating the potential of the next flash crash.	Study
Quote Stuffing (Egginton, Van Ness, Van Ness, 2012)	• Study examines the impact that quote stuffing has on market conditions by reviewing all trades and quotes for NYSE and NASDAQ listed stocks for all trading days in 2010. • Study finds that quote stuffing is pervasive; with several hundred events occurring each trading day and that 92% of NYSE and NASDAQ listed securities experienced at least one episode during 2010. • Study puts forth that during periods of intense quoting activity stocks experience decreased liquidity, high trading costs, and increased short term volatility.	Study

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News Trading and Speed (Foucault, Hombert, Rosu, 2011)	• Study puts forth that adverse selection occurs in financial markets because certain investors have either (a) more precise information, or (b) superior speed in accessing or exploiting information. • In an effort to disentangle the effects of precision and speed on market performance, the study compares two models in which a dealer and a more precisely informed trader continuously receive news about the value of an asset. In the first model the trader and the dealer are equally fast, while in the second model the trader receives the news one instant before the dealer. • Study finds that in the model in which the informed investor receives news faster, (1) the fraction of trading volume due to the informed investor increases from near zero to a large value; (2) liquidity decreases; (3) short-term price changes are more correlated with asset value changes; (4) informed order flow autocorrelation decreases to zero. However, the study finds that price volatility and price informativeness are the same, due to a substitution effect. In the fast model, there is more flow trading, but less level trading.	[Study](#)
Mini Flash Crashes (Golub, Keane, 2011)	• This paper considers the structural phenomenon in the equity markets termed mini flash crashes. Mini flash crashes are abrupt and severe price changes that occur in an extremely short period. • The goal of this paper is to study statistical properties of flash crashes using simple data mining techniques on tick-by-tick transaction data. • The authors investigate a number of relationships that have not been reported in previous works: i) the price movement behavior before crashes, ii) the influence of flash crashes on bid-ask spread, iii) the average price before the crash compared with the crash intensity and the effect of particular sectors and geographic region on the crash etc. • The authors put forth that when high frequency traders act in essence as market makers, they can contribute to downward price trend when an overabundance of sell orders are received and risk management limits are therefore breached, the market maker may stop providing liquidity and begin to aggressively take liquidity by selling back the shares it had bought moments earlier.	[Study](#)

Author	Positions/Key Points	Link
The Externalities of High-Frequency Trading (Gai, Yao, Ye, 2012)	• Study finds that the increasing the speed of trading from microseconds to nanoseconds does not lead to improvements on quoted spread, effective spread, trading volume and variance ratio. • Further, study finds an increase in the cancellation/execution ratio and an increase in short-term volatility and a decrease in market depth. • Study also finds evidence consistent with "quote stuffing," which involves submitting an extraordinary large number of orders followed by immediate cancellation in order to generate order congestion. • The study puts forth that the aggregate payoff by moving to nanoseconds is negative for both high-frequency traders and low-frequency traders. The study puts forth several suggestions to address the inefficiencies of such trading, such as (1) participants agreeing to not engage in such activities, (2) a Pigovian tax, and / or (3) to impose a cancellation fee.	Study
Low-Latency Trading (Hasbrouck, Saar, 2010)	• Using NASDAQ order-level data (two data samples: October 2007, June 2008), the study looks to examine the influence of low-latency traders on the market environment. • Study find that an increase in low-latency activity lowers short-term volatility, reduces quoted spreads and the total price impact of trades, and increases depth in the limit order book. • Study demonstrates that low-latency activity enhances market quality during both normal and periods of heightened uncertainty. However, it is noted that during periods of heightened uncertainty, during stressful times it appears to help reduce volatility in smaller stocks more than it does in larger stocks.	Study
Does Algorithmic Trading Improve Liquidity (Hendershott, Jones, Menkveld, 2011)	• Study reviews a sample of NYSE stocks starting from 2001-2005, with the authors finding that algorithmic trading does in fact improve liquidity for large-cap stocks. • Further, the authors argue that the study demonstrates that increased algorithmic trading lowers adverse selection and decreases the amount of price discovery that is correlated with trading (hence resulting in narrower spreads). • Study's results suggest that algorithmic trading lowers the costs of trading and increases the information contained in the quotes.	Study

Author	Positions/Key Points	Link
Algorithmic Trading and the Market for Liquidity (Hendershott, Riordan, 2012)	• Paper examines algorithmic trading impact by analyzing the 30 largest market capitalization stocks traded on the Deutsche Boerse (2008 data sample). • Paper finds that algorithmic trading consume liquidity when it is cheap and provide liquidity when it is expensive. • Further, paper finds that algorithmic trading contributes more to the discovery of the efficient price than human trading. • These results demonstrate that algorithmic trading closely monitor the market in terms of liquidity and information and react quickly to changes in market conditions. • Paper finds no evidence of algorithmic trading behavior that would contribute to volatility beyond making prices more efficient.	Study
Do High-Frequency Traders Anticipate Buying and Selling Pressure? (Hirschey, 2011)	• This study tests the hypothesis that HFTs have information about future order flow. • The author finds that HFTs' aggressive purchases predict future aggressive buying by non-HFTs, and their aggressive sales predict future aggressive selling by non-HFTs. • The positive correlation between trading by HFTs and future trading by other investors is robust to the exclusion of trading around intra-day news releases, indicating the effect is not driven by HFTs reacting to news announcements faster than other investors. There are also persistent differences among HFTs in the tendency of their trades to predict future order flow.	Study
A Dysfunctional Role of High Frequency Trading in Electronic Markets (Jarrow, Protter, 2011)	• Study provides a model where high frequency trading may play a dysfunctional role in financial markets. • The study indicates that high frequency traders can create a mispricing that they un-knowingly exploit to the disadvantage of ordinary investors. This mispricing is generated by the collective and independent actions of high frequency traders, coordinated via the observation of a common signal.	Study

Author	Positions/Key Points	Link
Financial Black Swans Driven by Ultrafast Machine Ecology (Johnson, Zhao, Hunsader, Meng, Ravindar, Carran, Tivnan, 2012)	• This study analyzes a set of 18,520 ultrafast black swan events that have been uncovered in stock-price movements between 2006 and 2011. • The authors' provide empirical evidence for, and an accompanying theory of, an abrupt system wide transition from a mixed human-machine phase to a new all-machine phase characterized by frequent black swan events with ultrafast durations (650ms for crashes and 950ms for spikes). • The authors' find that that the ten most susceptible entities are major international banks, hints at a hidden relationship between these ultrafast 'fractures' and the slow 'breaking' of the global financial system post-2006. • Overall the authors' work provides tools to help predict and mitigate the systematic risk developing in any complex socio-technical system that attempts to operate at, or beyond, the limits of human response times.	[Study](#)
What Do We Know About High-Frequency Trading? (Jones, 2013)	• Study reviews the recent theoretical and empirical research on high-frequency trading and finds that HFT and automated, competing trading venues have substantially improved market liquidity and reduced trading costs for all investors. • Study finds that HFT speed could disadvantage other investors, and the resulting adverse selection could reduce market quality. • Further, study states that HFT has sharply increased competition in market-making, and bid ask spreads are much narrower as a result. Stock prices are more efficient as a result of HFT activity. Overall, there is no evidence of any adverse effect due to HFT in the average results. • However, the study notes that there is a concern supported by data, that HFT may not help stabilize prices during unusually volatile periods. However, there are many historical cases where intermediaries step aside at times of extreme volatility, so this appears to be a fairly generic feature of equity markets rather than a specific problem with HFT. • Study notes that the regulatory issues associated with HFT are the same issues that arose during more manual markets. Now regulators in the US are appropriately relying on competition to minimize abuses. • Other regulation is appropriate if there are market failures. For instance, consolidated order-level audit trails are key to robust enforcement. If excessive messages impose negative externalities on others, fees are appropriate. But a message tax may act like a transaction tax, reducing share prices, increasing volatility, and worsening liquidity. Minimum order exposure times would also severely discourage liquidity provision.	[Study](#)

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Middlemen in Limit Order Markets (Jovanovic, Menkveld, 2010)	• Middlemen can enhance welfare as their speed advantage helps to 'unlock' an adverse-selection induced trade deadlock. High frequency traders stand out by their superior information processing speed established through efficient algorithms that run on fast computers 'co-located' at a market's server. This creates an edge in terms of quickly updating limit orders on the arrival of public information. In the deadlock example, the early investor might sell to the middleman who keeps refreshing his limit sell until the late investor arrives. • Middlemen might reduce welfare if their speed creates an adverse selection risk for limit order that might not have otherwise existed. If the late investor is unaware of a common value innovation, trade is not hampered by adverse selection. If middlemen are introduced in this setting, they create an adverse selection risk for the early investor and might reduce trade. • The results of HFT entry are mixed: the entry of a HFT tends to lower spreads, but lower volume was noticed as well (either due to investors shying away from the market or intermediaries being replace by HFTs).	[Study](#)
The Impact of High-Frequency Trading on Stock Market Liquidity Measures (Kim, Murphy, 2011)	• The authors examine potential misspecification in four commonly used empirical market microstructure models by comparing the model-implied effective spreads with the corresponding observed effective spreads for the S&P 500 exchange traded fund (SPY) for the period 1997-2009. • The authors' believe that the increase in magnitude of underestimation in the latter period is caused by significant changes in patterns after 2006: The average trade size declined from 2,700 shares during 1997-2006 to 400 shares during 2007-2009, and at the same time, the average number of consecutive buys or sells has increased from 4 to 12. • The paper's evidence suggests that with the advent of high frequency trading, it has become increasingly common to split up large orders into many smaller-sized orders and direct them to different trading venues. • The authors' conclude that by aggregating strings of consecutive buys or sells, due to the fact that it has become increasingly common for traders to split up their large orders, the authors' improve the ability to model the price change process and produce accurate measures of the effective bid-ask spread	[Study](#)

Author	Positions/Key Points	Link
The Flash Crash: The Impact of High Frequency Trading on an Electronic Market (Kirilenko, Kyle, Samadi, Tuzun, 2011)	• Study notes that High Frequency Traders aggressively trade in the direction of price changes. This activity comprises a large percentage of total trading volume, but does not result in a significant accumulation of inventory. • As a result, whether under normal market conditions or during periods of high volatility, High Frequency Traders are not willing to accumulate large positions or absorb large losses. Moreover, their contribution to higher trading volumes may be mistaken for liquidity by Fundamental Traders. • When rebalancing their positions, High Frequency Traders may compete for liquidity and amplify price volatility. • Paper concludes that HFTs did not trigger the Flash Crash, but their responses to the unusually large selling pressure on that day exacerbated market volatility.	Study
High Frequency Traders, News and Volatility (Martinez, Rosu, 2011)	• Study shows that HFTs generate a large part of the trading volume and price volatility. • Study also notes that when the number of HFTs increases, volatility stays constant, while volume and liquidity increase. • Further, when the HFTs' news precision increases, volatility and volume increase, while liquidity decreases. The study's model therefore provides an explanation why trading volume and volatility increase after news announcements, even though there is perfect agreement among informed traders. • Study states that HFTs are traders that make the market extremely efficient, by incorporating information as soon as it becomes available. This does not destabilize markets, as long as there exists a population of market makers ready to provide liquidity and to set prices in an actuarially fair manner.	Study
Strategic Liquidity Supply in a Supply Market with Fast and Slow Traders (McInish, Upson, 2012)	• The authors' model and show empirically that latency differences allow fast liquidity suppliers to pick off slow liquidity demanders at prices inferior to the NBBO. This trading strategy is highly profitable for the fast traders. The authors' estimate that the fast traders earn more than $223 million per year at the expense of the slow traders. • The authors' show that when this market became faster, execution quality improved markedly for fast liquidity demanders, but improved only minimally for slow liquidity demanders. • The authors' analysis indicates that as markets become faster, fast liquidity demanders are better able to avoid trading at Flicker Prices. However, fast liquidity suppliers are also better able to target slow traders at Flicker Prices, earning cents.	Study

Author	Positions/Key Points	Link
High Frequency Trading and the New-Market Makers (Menkveld, 2013)	• To evaluate the characteristics of an High Frequency Trader (HFT), the paper utilizes proprietary Chi-X and Euronext datasets that contain anonymized broker IDs for trades in Dutch index stocks for a sample period that runs from September 4, 2007 to June 17, 2008. • Paper finds that in each market, four out of five of its trades are passive, i.e., the HFT was the (liquidity-supplying) limit order in the book that got executed. Paper notes that on average, a HFT trades 1397 trades per stock per day. It makes money on the spread but loses money on its positions • Paper further shows how fees are a substantial part of a high-frequency trader's profit and loss account. It is therefore not surprising that new, low-fee venues have entered the exchange market as they are attractive to these 'modern' market makers. It is shown that such lower fees are, at least partially, passed on to end users through lower bid-ask spreads.	Study
Competing on Speed (Pagnotta, Philippon, 2011)	• Study finds that those markets that leverage regulations to protect asset prices will lead to fragmentation and faster trading speeds. • Study finds that to a certain extent, faster trading is in general socially desirable. Further, at a certain level of trading speed, competition among exchange increases participation and gains from trading efficiency are large. However, when the default speed of trading is high, the perceived gains and advantages of competition are no longer present.	Study
Is High-Frequency Trading Inducing Changes in Market Microstructure and Dynamics? (Smith, 2010)	• Paper investigates whether the effects of the onset of high-frequency trading are apparent in the dynamics of the dollar traded volume by reviewing the intraday activity of a sample of liquid NYSE and NASDAQ stocks from 2002-2009. • Paper finds that high frequency trading is having an increasingly large impact on the microstructure of equity trading dynamics; specifically increased volatility in the stocks sampled. • Paper notes that this shift is linked both temporally to the Reg NMS reforms allowing high-frequency trading to flourish as well as to the declining average size of trades with smaller trades showing markedly higher degrees of self-similarity.	Study

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Crashes and High Frequency Trading (Sornette, Von der Becke, 2011)	• Study reviews the potential for bubbles and crashes associated with high frequency trading. • Study argues that high frequency trading has lead to crashes in the past and it can be expected to do again in the future. • Further, as a consequence of the increasing inter-dependences between various financial instruments and asset classes, the study suggests that one can expect in the future more flash crashes involving additional markets and instruments. • Study questions the argument that HFT provides liquidity and suggest that the welfare gains derived from high frequency trading are minimal and perhaps even largely negative on a long-term investment horizon. • Study notes that high frequency traders can also be significant liquidity takers and, secondly, that there are indications that larger liquidity increases herding effects and crashes thereby potentially reducing the value the real economy derives from liquidity above a certain threshold. • In addition, the study argues that it is conceivable that liquidity reaches a point beyond which the real economy does not benefit anymore and where additional liquidity increases the risk of herding, of strong correlations, possibly leading to systemic instabilities and ultimately to crashes and their aftermath.	Study
Latency, Liquidity and Price Discovery (Riordan, Storkenmaier, 2011)	• Study uses a sample containing 110 stocks that make up the Deutsche Boerse's HDAX, with an observation period of 2/2007 – 6/2007. • Results of the study show that decreasing the latency in a market leads to increased liquidity. • The authors' state that the general fear of, and aversion to, increased market automation and offerings like co-location are misplaced. • However, the authors' do note that market operators would do well to note that while prices appear to be more efficient, changes in competition of this magnitude may have unforeseen consequences. • Lastly, the authors' argue that market operators should develop ways to encourage competition between liquidity suppliers. Perhaps offering rebates not only for passive executions (as on NASDAQ) but also for investors that improve the bid or ask or are consistently offering the best prices in the market.	Study

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Liquidity: What You See is What You Get? (Van Kervel, 2012)	- The author's model shows that liquidity offered on the limit order books combined may strongly overestimate the actual liquidity available to investors. - The excess is caused by high frequency traders operating as market makers, who may duplicate their limit order schedules on several venues to increase their execution probabilities. Then after a trade on one venue they will quickly cancel outstanding limit orders on others. The magnitude of the cancellations depends on the fraction of investors that may access several venues simultaneously, for example those who use Smart Order Routing Technology (SORT). - The reason is that market makers incur higher adverse selection costs when the investor trades at a competing venue first. As a result a higher fraction of SORT investors reduces the incentives of market makers to place duplicate limit orders. - The empirical results confirm the main prediction of the model, as trades on the most active venues are followed by cancellations of limit orders on competing venues of more than 53% of the trade size.	Study
High-Frequency Trading, Stock Volatility, and Price Discovery (Zhang, 2010)	- Study reviews a sample of all stocks covered by the CRSP and Thomson Reuters Institutional Holding databases between 1985 and 2009. - The study found that high frequency trading is positively correlated with stock price volatility, particularly among the top 3,000 stock in market capitalization and among stocks with high institutional holdings. - Further, the study's results indicate that high frequency trading is negatively related to the market's ability to incorporate information about firm fundamentals into asset prices. - In addition, the study indicates that stock prices tend to overreact to fundamental news when high frequency trading is at a high volume. - Lastly, the study demonstrates that high frequency trading may potentially have some harmful effects for the U.S. capital market.	Study