

Contents

Preface	3
Research Highlights	4
Volatility	4
Manipulation	6
Market Quality	6
Investor Costs	8
Evidence-Based Research Bibliography.....	10
The Wall Street Journal's "Dark Market" Series (selected articles)	40
High Frequency Trading and "Insider Trading 2.0"	42
Press Editorials	43
Op-Eds and Commentary	45
Books and Documentaries	57
"Flash Boys" by Michael Lewis	60
60 Minutes.....	60
Reviews.....	60
CNBC	61
Interviews	61
Other Interviews	62
"Flash Boys": Supporting Evidence	62
Government Reaction to HFT	64
Central Banks.....	64
Regulators.....	66
Legislators.....	69
Prosecutors	70
Other	70
High Frequency Trading Defined	71
Industry Participants.....	71
Academics.....	71
Regulators.....	72

Preface

This is the fifth edition of a research bibliography on the negative effects of high frequency trading (HFT). It includes a wide variety of academic, government, and industry data-driven research from institutions around the world, including MIT, Harvard, Princeton, the Federal Reserve Bank, the Bank of England, the University of Chicago, BlackRock, Cornell, the SEC, the European Central Bank, Yale, Oxford, Cambridge, the London School of Economics, the United Nations, the International Monetary Fund, and many others.

HFT research is especially relevant after the events of October 15, 2014, when yields on U.S. Treasuries flash crashed, and the events of August 24, 2015, when U.S. stock markets suffered their second trillion dollar flash crash in five years. Among other topics, research posted here explores how the most common high frequency trading business model today - unregulated or poorly regulated market making, often called "scalping" - can be abusive and disruptive. Several of these studies even predate automation.

Along with evidence-based research, separate sections of this bibliography include press editorials, op-eds, other commentary, and a variety of statements from government bodies and government officials from around the world about high frequency trading.

This document begins with an overview and research highlights. A detailed research bibliography containing nearly 150 studies follows the highlights. Significant critical study findings are summarized or quoted in the highlights and the detailed bibliography. While this bibliography summarizes and excerpts critical findings, some studies cited here show mixed effects about high frequency trading. Interested readers can link to the full text of almost every included work.

Please also note various industry, academic, and government definitions of high frequency trading listed in the final section of this document, and note the special section on Michael Lewis's "Flash Boys."

R. T. Leuchtkafer
March 2016

Research Highlights

Volatility

In a [2010 study of the 2010 Flash Crash](#), the **U.S. Securities and Exchange Commission** and the **Commodity Futures Trading Commission** found that high frequency traders substantially increased volatility during the event and accelerated the crash. [Kirilenko et. al.](#) (2014) studied the 2010 Flash Crash and found the same, concluding that high frequency traders "can amplify a directional price move and significantly add to volatility." [Menkveld and Yueshen](#) (2015) confirmed the U.S. government's and Kirilenko's narratives about the Flash Crash. The **U.S. Treasury**, the **Board of Governors of the Federal Reserve System**, the **Federal Reserve Bank of New York**, the **U.S. Securities and Exchange Commission** and the **U.S. Commodity Futures Trading Commission** released a [Joint Staff Report](#) about events on October 15, 2014, when "the market for U.S. Treasury securities, futures, and other closely related financial markets experienced an unusually high level of volatility." The report found high frequency trading firm strategies "aggressively traded in the direction of price moves during the event window, accounting for the bulk of the overall aggressive trading imbalance observed."

[Madhavan](#) (2012) examined almost two decades of U.S. equities data and wrote that "The link to higher frequency quotation activity and the current high levels of fragmentation help explain why a Flash Crash did not occur before and offers a counterpoint to the view that the Flash Crash stemmed from an unlikely confluence of events." The [Australian Securities and Investments Commission](#), the stock market regulator in Australia, found in a 2013 study that during volatile markets high frequency traders reduce their liquidity supply and increase their liquidity demands. After studying a decade's worth of U.S. data, [Hasbrouck](#) (2015) found that high frequency quoting increased a measure of intraday volatility by a factor of two or more.

The [Bank for International Settlements](#) looked at foreign exchange markets and concluded in a 2011 study that high frequency traders exacerbate volatility in stressed markets. In 2016 the [Bank for International Settlements](#) published a study of the recent evolution of sovereign debt markets and found that because of the adoption of algorithmic and high frequency trading "some market participants have highlighted that while liquidity is ample in normal times, it may have become more fragile in episodes of heightened demand for trading immediacy." [Ben-David et. al.](#) (2012) studied 14 years of U.S. equity data and concluded that "HFT can be highly destabilizing as it propagates shocks across markets at very high speed." [Bichetti et. al.](#) (2012) examined 15 years of U.S. equities and futures data and determined that HFT strategies cause assets to "deviate from their fundamentals." [Boehmer et. al.](#) analyzed nine years of stock market data from 37 countries and in a 2012 paper concluded that algorithmic trading, including high frequency trading, caused higher volatility. [Zhang](#) (2010) studied 25 years of U.S. stock market data and determined "high-frequency trading is positively correlated with stock price volatility." [Huh](#) (2014) found that high frequency traders withdraw during volatile markets, which exacerbates volatility. [Kang and Shin](#) (2012) looked at the Korean futures markets and concluded that "massive use of limit orders including revision and cancellation by high frequency traders may potentially have negative effects on the market." In Italy, [Caivano](#) (2015) found that "HFT activity causes a statistically and economically significant increase in volatility."

The [U.K. Government Office for Science](#) published a large 2012 study of capital markets around the world and concluded that "HFT/AT may cause instabilities in financial markets in specific circumstances." [Golub et. al.](#) (2012) looked at six years of U.S. stock market data to study mini flash crashes and determined that "Given the speed and the magnitude of the crashes, it appears likely that Mini Flash Crashes are caused by HFT activity." [Easley et. al.](#) (2011) found that high frequency traders can

exacerbate price volatility when they dump inventory and withdraw from volatile markets, and that flash crashes will recur because of U.S. market structure. [Chung et. al.](#) (2012) studied U.S. stock market data from two decades and wrote that higher volatility in asset prices in recent years is due in part to "the increased role of high-frequency traders." [Breckenfelder](#) (2013) studied Swedish equities and found that intraday volatility increased substantially when high frequency firms came to Sweden. [Bain and Mudassir](#) (2013) found that though high frequency traders might narrow spreads, they increase intraday volatility, and noted "an approximate doubling of short-term volatility resulting in higher implicit execution costs for investors." [Brogaard et. al.](#) (2015) examined U.S. stock market data and concluded "Overall HFTs' trading and HFTs' short selling decreases liquidity by adversely selecting liquidity suppliers....Hence, a conservative interpretation of the results is that a component of HFTs' activity that is harmful. Consistent with a number of theoretical papers, the results suggest that a policy response to HFTs could include restrictions on HFTs."

[Benos and Sagade](#) (2012) found that aggressive high frequency trading increased volatility in U.K. stock markets. [Benos and Weatherilt](#) (2012) found that "the de facto high-frequency market makers that have entered markets following technological advances are free to enter or exit the market at will. This allows them to compete with DMMs when market-making is profitable but withdraw altogether from the market when it is not..." [Nanex](#) (2010-2016) has analyzed U.S. trading data from 2006 onward and found thousands of events where individual stocks experienced unexplained violent price swings. [Weller](#) (2012) looked at U.S. futures data and wrote that "the introduction of fast, low capital intermediaries [high frequency traders] can render markets less able to bear large liquidity demand shocks." The [Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues](#) (2011), which included two Nobel laureates, examined U.S. market structure and data from the Flash Crash and wrote "In the present environment, where high frequency and algorithmic trading predominate and where exchange competition has essentially eliminated rule-based market maker obligations, liquidity problems are an inherent difficulty that must be addressed. Indeed, even in the absence of extraordinary market events, limit order books can quickly empty and prices can crash simply due to the speed and numbers of orders flowing into the market and due to the ability to instantly cancel orders." [Golub et. al.](#) (2012) examined U.S. equities data from 2006 through 2011 and found "strong evidence that Mini Flash Crashes have an adverse impact on market liquidity and are associated with Fleeting Liquidity." [Raman et. al.](#) (2014) looked at U.S. futures data and concluded that "in sharp contrast to the erstwhile locals in futures pits, electronic market makers reduce their participation and their liquidity provision in periods of significantly high and persistent volatility....our results raise the question whether exchanges and regulators should consider affirmative obligations for hitherto voluntary market makers." The [United States Department of the Treasury et. al.](#) (2015) studied Treasuries and futures trade data and noted "Another, and equally significant, group of PTF [high frequency trading firm] strategies appears to have aggressively traded in the direction of price moves during the event window, accounting for the bulk of the overall aggressive trading imbalance observed." The [United States Federal Reserve Bank of New York's Treasury Market Practices Group](#) (2015) studied Treasuries and futures trade data and concluded "the increased adoption of automated trading has also led market participants and regulators to articulate concerns about the potential for greater operational risk, disruptive market practices and trading strategies, and the risk of sharp, short-term disruptions to the Treasury securities market of the kind experienced in the equities and futures markets, which have a significant automated trading presence."

Manipulation

[Egginton et. al.](#) (2012) found systematic evidence of "quote stuffing," a term coined by the market data and research firm Nanex to describe the many events it found where exchange technology infrastructure was slowed by floods of order and order cancel activity. They wrote that "We find that quote stuffing is pervasive with several hundred events occurring each trading day and that quote stuffing impacts over 74% of US listed equities during our sample period," and found that "stocks experience decreased liquidity, higher trading costs, and increased short term volatility." [Gao et. al.](#) (2015) studied U.S. markets from 2008 to 2013 and found "quote stuffing is harmful to market quality: prices become more volatile and bid-ask spreads rise." [Direct Edge](#) (2013) launched a service to help its customers "mitigate the risks" of quote stuffing. [Tse et. al.](#) (2012) "present a detailed study of a variety of negative HFT strategies including examples of Quote Stuffing, Layering/Order Book Fade, and Momentum Ignition to demonstrate what bad HFT 'looks like', how often it happens, and how we detect it." [Ye et. al.](#) (2013) analyzed U.S. stock market data from 2010 and found "that stocks randomly grouped into the same [technology] channel have an abnormal correlation in message flow, which is consistent with the quote stuffing hypothesis." Industry regulator [FINRA](#) (2014) alleged a firm's high frequency trading customers employed "aggressive, potentially destabilizing trading strategies in illiquid securities." The [United States Securities and Exchange Commission](#) (2014) sanctioned a high frequency trading firm for manipulating the closing prices of thousands of stocks over a six month period. The [United States Commodity Futures Trading Commission](#) fined a trading firm \$2.8 million for a "computer algorithm that was designed to illegally place and quickly cancel bids and offers in futures contracts." The [United States of America](#) indicted (and later convicted) a trader who had "devised, implemented, and executed a high-frequency trading strategy in which he entered large-volume orders that he intended to immediately cancel before they could be filled by other traders." The French regulator [Autorité des Marchés Financiers](#) fined a global high frequency trading firm €5 million because its "huge volumes of extremely rapid messages in the order books of the 27 securities gave, or were likely to have given, false or misleading indications as to the supply and demand for those financial instruments, constituting a market manipulation as laid down in Article 631-1 of the AMF General Regulation."

Market Quality

[Baron et. al.](#) (2014) studied U.S. futures data and found a "winner-takes-all market structure" where "HFTs have strong incentives to take liquidity and compete over small increases in speed in an industry dominated by a small number of incumbents earning high and persistent returns." [Biais and Foucault](#) (2014) "recommend developing trading mechanisms that cater specifically to slow traders" and said "This could require regulatory intervention to overcome exchanges' conflict of interests." [Kim and Murphy](#) (2013) examined more than a decade of U.S. stock market data and found that after controlling for changes in market dynamics in that time period, market spreads were much worse than have been reported. [Kirilenko and Lo](#) (2013) surveyed the research literature and concluded that "In contrast to a number of public claims, high frequency traders do not as a rule engage in the provision of liquidity like traditional market makers." [Lee](#) (2013) analyzed Korean futures data and found that "high frequency trading is detrimental to the price discovery process." [Machain and Dufour](#) (2013) investigated U.K. stock market data and found empirical evidence for "a minimum period of time a limit order should be kept on the order book to avoid speculative practices." [McInish and Upson](#) (2012) explored U.S. equity data and wrote that "the ability of fast liquidity suppliers to use their speed advantage to the detriment of slow liquidity demanders...unambiguously lowers market quality." [Yildiz et. al.](#) (2014) "provide empirical evidence to support the theoretical predictions...that HFTs may play a dysfunctional role in financial markets." [Van Kervel](#) (2014) studied U.K. data and found that "trades are followed by excessive cancellations of limit orders, and the magnitude depends on the fraction of traders who can access

several venues simultaneously" and "high-frequency traders can observe the first part of the trade and quickly cancel outstanding limit orders on other venues before the second part of the trade arrives." After analyzing U.S. stock market data, [Ye et. al.](#) (2013) concluded that speed improvements do not improve spreads but do increase cancellations and volatility. [Johnson et. al.](#) (2013) "uncovered an explosion of UEEs [ultrafast extreme events] starting in 2006, just after new legislation came into force that made high frequency trading more attractive."

The [Australian Securities and Investments Commission](#) (2013) reported that it found "some examples of potentially predatory activity" and that it aggressively intervened with high frequency trading firms to change their trading practices. Its efforts caused a "behavioural change by traders which has had a marked effect on market quality," including a 40% reduction in volatility in one part of the trading day. Analyzing Australian equities markets, [Kwan and Philip](#) (2015) attributed increased trading costs to "more predatory trading by HFT....we show that HFT are more successful in front-running non-HFT limit orders." [Partington et. al.](#) (2015) found that "evidence suggests that HFT trading strategies are likely to detract from, rather than add to, market quality." [Boehmer et. al.](#) (2012) studied trading data from around the world and discovered that "algorithmic traders can have impact beyond the immediate trading environment and potentially affect the more fundamental functions of capital markets, such as the allocation of capital to firms." [Boni et. al.](#) (2012) found that excluding high frequency traders from a market center resulted in lower volatility, less front running, and higher execution quality for institutional traders. [Boulton et. al.](#) (2012) analyzed U.S. stock market data from 2010 and discovered that "seemingly fleeting events, such as the flash crash, can have dramatic and lingering effects on shareholder wealth and market quality." [Clark-Joseph](#) (2013) explored U.S. futures data and found that "Aggressive trading is a tremendously important component of HFTs' activity. In aggregate, approximately 48.5% of HFTs' volume is aggressive, and this figure rises to 54.2% among the 12 largest HFTs." [Gerig](#) (2015) studied U.S. equities and concluded that "HFT appears to make the financial system as a whole more fragile."

[Nasdaq](#) (2012) "observed that upon partial execution of a routable order at NASDAQ...market participants often react to the order by cancelling their orders on other markets and entering new orders at inferior prices." (A senior executive of a high frequency market maker, who is also head of an industry lobbying group, not long ago wrote "If I quote on 8 exchanges and get hit on one, I will update 16 prices. That is main reason for high [cancel] rates," offering strong evidence for Nasdaq's point; he then later confessed "market makers offer more liquidity than they're prepared to trade in one go.") [Nanex](#) (2014) analyzed the impact of one trader's order and found "sell orders simply disappeared before the exchanges processed his buy order."

For a \$12 million penalty, Knight Capital, one of the largest high frequency market makers in the world, settled charges in October 2013 with the [U.S. Securities and Exchange Commission](#) that Knight "did not have adequate safeguards in place to limit the risks posed by its access to the markets, and failed as a result to prevent the entry of millions of erroneous orders." For a combined \$375,000 penalty, the U.S. subsidiary of the Dutch firm IMC, one of the largest high-frequency market makers in the world, settled charges in April 2013 with four U.S. stock exchanges including [Nasdaq](#) (2013) that it failed "to establish and maintain adequate supervisory procedures, including written supervisory procedures, and a reasonable system of follow-up and review, related to the oversight of the Firm's high frequency and algorithmic trading," as one of the settlements detailed. In July 2012, the [Hong Kong Securities and Futures Commission](#) fined an IMC subsidiary HK\$1.5 million for "regulatory breaches and internal control failings." For a \$450,000 penalty, Getco, one of the largest high frequency market makers in the world, settled charges in March 2012 with [Nasdaq](#) that one of its subsidiaries "failed to establish and maintain a reasonable supervisory system, including but not limited to its written supervisory procedures

and supervisory and operational risk control systems related to the oversight and operation of high frequency trading and algorithmic trading." The [CBOT](#) found that a firm let a malfunctioning system run uninterrupted for 90 minutes while it sent "an excessive number of orders and cancel messages...[accounting for] 88% of the messaging volume in the contract" and shut the system down only after the exchange contacted the firm.

In July 2013 [FINRA](#) and four U.S. exchanges fined Newedge USA a total of \$9.5 million because the firm "failed to establish, maintain and enforce adequate supervisory systems and procedures, including written supervisory procedures that were reasonably designed to achieve compliance with applicable securities laws and regulations, including FINRA and exchange rules, addressing anti-money laundering and other potentially manipulative and suspicious trading activity by the Firm's DMA [electronic direct market access] and SA [sponsored access] clients, such as spoofing, marking the close, excessive repetitive order entry, and wash sale transactions, numerous instances of which may have occurred on as many as four exchanges." In November 2011 the [CME Group](#) fined Infinium Capital Management a total of \$850,000 because, in part, the firm allowed "a malfunctioning ATS [automated trading system] to operate in a live trading environment." In August 2013 the [China Securities Regulatory Commission](#) fined Everbright Securities \$85 million for "serious flaws" in its trading systems and controls that "directly affected the normal order of securities markets and caused violent stock price fluctuation" that jolted investors.

The [U.S. Federal Reserve Bank of Chicago](#) studied a variety of proprietary trading firms, including high frequency firms, and wrote in 2012 that "some firms do not have stringent processes for the development, testing, and deployment of code used in their trading algorithms" and that "out-of-control algorithms were more common" than it expected.

The [United States Securities and Exchange Commission](#) (2015) levied its largest fine ever against a stock exchange for giving "information about certain order types only to some members, including certain high-frequency trading firms that provided input about how the orders would operate"; in 2016, it levied its [largest fines ever against dark pools](#) for misleading subscribers about their operations.

Investor Costs

The **Industry Super Network** is an association of Australian mutual funds. In a [2013 study](#), it estimated that high frequency traders cost long-term Australian investors an average A\$1.6 billion a year. In the Australian equities markets [Kwan and Philip](#) (2015) attributed increased trading costs to "more predatory trading by HFT....we show that HFT are more successful in front-running non-HFT limit orders." [Norges Bank Investment Management](#) (2013), one of the largest funds in the world with nearly \$1 trillion under management, surveyed the research literature and concluded that "issues of concern to large, long-term investors more deserving of attention include — Anticipation of large orders by some HFTs leading to potential adverse market impact — Transient liquidity due to high propensity for HFTs to rapidly cancel quotes real-time — Un-level playing field amongst market makers from low latency ultra HFT strategies." [Pragma Securities](#) (2012) examined U.S. stock trading in 2011 and 2012 and concluded that "high frequency traders' profits come at the expense of investors." [Wah](#) (2015) studied U.S. stock market data and estimated "that total potential profit from latency arbitrage opportunities in S&P 500 ticker symbols was approximately \$3.03 billion in 2014."

[Nanex](#) (2013) detailed episodes where high frequency traders had market-moving information worth millions ahead of other investors despite widespread beliefs they did not. [Rogers et. al.](#) (2015) found that the SEC provided corporate filings to high-speed traders before providing them to the public.

[McInish and Upson](#) (2012) looked at U.S. stock market data and "show empirically that latency differences allow fast liquidity suppliers to pick off slow liquidity demanders at prices inferior to the NBBO." [Hirschev](#) (2013) examined U.S. stock market data and wrote that his analysis provides "evidence supporting the existence of an anticipatory trading channel through which HFTs may increase non-HFT trading costs." [Gao and Mizrach](#) (2013) found that high frequency traders are more profitable when they trade against long-term investors than when they trade with other high frequency firms. The [Quantitative Services Group](#) (2010) examined U.S. equity data and reported that "Changes in the microstructure of equity markets and the emergence of HFT competitors have changed the nature and magnitude of transaction costs. Sophisticated pattern recognition algorithms now present a real return burden to active equity managers." [Weller](#) (2016) studied U.S. stock market data and found that "Although algorithmic liquidity provision may be associated with increased information acquisition, its effects are swamped by the damage wrought by aggressive algorithmic traders."

[Tong](#) (2013) studied U.S. stock data and found "strong evidence that HFT increases the trading costs of institutional investors." [Brogaard et. al.](#) (2012) studied U.K. equities data from 2007 to 2011 and found that while institutional trading costs had declined in the period, high frequency trading had nothing to do with it. [Budish et. al.](#) (2015) looked at U.S. futures and equities data from 2005 to 2011 and found "These arbitrage rents also induce a never-ending speed race....The size of the arbitrage opportunity, and hence the harm to investors via reduced liquidity, depends neither on the magnitude of the speed improvements (be they milliseconds, microseconds, nanoseconds, etc.), nor on the cost of cutting edge speed technology (if speed costs get smaller over time there is simply more entry)." [Ding et. al.](#) (2013) compared the relative speeds of national utility data feeds (typically used by long-term investors) and exchange proprietary data feeds (typically used by high frequency traders) and found a substantial advantage for the proprietary data feeds, "While price dislocations have small effects on infrequently trading investors, investors that are continuously in the market [such as mutual funds] can be substantially disadvantaged." [Menkveld and Zoican](#) (2014) analyzed several European equities markets and wrote "a faster market implies more interaction among HFTs, i.e., their market participation increases and, more importantly, transaction cost for 'low frequency' investors increases as a result." [Toulson](#) (2013) examined European equities and found that HFT firms reacted to asset manager orders by cancelling their own orders and trading in front of the asset manager. [Van Kervel and Menkveld](#) (2016) studied Swedish equities and concluded that "HFTs seem to run on the most informed orders. HFT [front running] on institutional orders does not necessarily improve market quality. One could argue that prices become more efficient in the short run. HFT trading in the same direction as informed investors makes prices reveal private information more quickly. The worrisome side effect is that, in the long run, prices could become less efficient." [Malinova and Park](#) (2015) analyzed Canadian equities data and found that "Overall, our analysis indicates that after, say, trading with a buyer, market-makers cancel their sell orders quickly and submit aggressive buy orders." [Korajczyk and Murphy](#) (2015) looked at Canadian equities and found that it is "possible that an HFT 'frontruns' these large orders, in that the HFT buys (sells) ahead of a large stressful buy (sell) and subsequently sells to (buys from) the large trader at a higher (lower) price." [Saglam](#) (2015) studied "the impact of an exogenous trading glitch in a high-frequency market--making firm on institutional trading costs" and found "substantially higher costs on the event day. Moreover, the cost increase is persistent up to one week roughly with the same additional cost magnifying the total economic costs."

Evidence-Based Research Bibliography

Author(s), Title, Year, Affiliation (first author)	Evidence	Relevant critical findings
Anand, Tanggaard, Weaver, " Paying for Market Quality " (2009) Syracuse University	Swedish equities, 2002-2004	Designated market makers with affirmative obligations improve market quality, increase market valuation.
Australia Industry Super Network, " Some Costs of High Frequency Trading in Low Latency Markets " (2013)	Australian equities, 2012	"ISN estimates that HFT activities cost non-HFT market participants, including Australian long-term investors such as super funds [mutual funds], up to \$1.9 billion per year, with a best estimate of over \$1.6 billion per year."
Australian Securities and Investments Commission, " Report 331: Dark liquidity and high-frequency trading " (2013)	Australian equities, 2012	"High-frequency traders reduce their passive liquidity provision (price-making) during relatively volatile periods, but remain active as liquidity takers."; "Our analysis of high-frequency liquidity has detected some examples of potentially predatory activity...The traders, in these instances, have, in some cases responded positively to our intervention by modifying their algorithms, ceasing all trading in the market and in other cases they have been referred to Enforcement for investigation. In any case, we have seen behavioural change by traders which has had a marked effect on market quality."
Autorité des Marchés Financiers, " AMF Enforcement Committee sanctions Virtu Financial Europe and Euronext Paris " (2015)	European equities, 2009	"On 4 December 2015, the Enforcement Committee handed down a penalty of €5 million to Virtu Financial Europe for market manipulation and ignoring Euronext market rules. It also handed down a penalty in the same amount to Euronext Paris for failing to meet its obligation to operate with neutrality and impartiality, in accordance with market integrity."
Bain, Mudassar, " Evolution of Canadian Equity Markets " (2013) RBC Capital Markets	Canadian equities, 1996-2013	"Our study shows that the apparent benefits of higher volume and narrower spreads have come at the expense of increased relative intraday trading volatility. We believe this volatility constitutes a substantial hidden cost for natural investors and raises serious questions about the true costs and benefits of narrowed spreads."
Bank for International Settlements, " High frequency trading in the foreign exchange market " (2011)	Foreign exchange, 2010 and 2011	"HFT has had a marked impact on the functioning of the FX market in ways that could be seen as beneficial in normal times, but also in ways that may be harmful to market functioning, particularly in times of

market stress."

Bank for International Settlements, "Electronic trading in fixed income markets" (2016)	Market participant interviews, US Treasuries 2004-2015, UK and Euro area government securities 2008-2015, literature review	"The adoption of AT and HFT and continued influx of new market participants may create new price and liquidity dynamics. In some jurisdictions and markets, this has ensured very tight bid-ask spreads. However, this limited perspective may create a misleading impression of market quality. In fact, some market participants have highlighted that while liquidity is ample in normal times, it may have become more fragile in episodes of heightened demand for trading immediacy."
Baron, Brogaard, Kirilenko, "Risk and Return in High Frequency Trading" (2014) Princeton University	U.S. futures, 2010-2012	Large, established HFT firms trump new competition; the industry over time stays concentrated in a few hands; measures of industry concentration are as high or higher than in the "bad old days"; "HFT returns are highly persistent, while risks are kept very low through tight inventory control and rapid turnover of contracts. HFT profits accumulate to the fastest and most aggressive liquidity-taking incumbents, while new entrants are less profitable and more likely to exit...Our results suggest that HFTs have strong incentives to take liquidity and compete over small increases in speed in an industry dominated by a small number of incumbents earning high and persistent returns." See also "Testimony of Andrei Kirilenko Professor of the Practice of Finance Sloan School of Management Massachusetts Institute of Technology Before the Senate Committee on Agriculture, Nutrition & Forestry Hearing on High Frequency and Automated Trading in Futures Markets." May 13, 2014
Ben-David, Franzoni, Moussawi, "ETFs, Arbitrage, and Shock Propagation" (2012) Ohio State University	U.S. equities 1998-2011	"[O]ur results also provide support for the claim that high-frequency trading has the potential to rapidly propagate liquidity shocks across markets."; "As much of ETF arbitrage is carried out at high frequencies, the evidence in the paper seems to suggest that HFT adds to the non-fundamental volatility of asset prices, at the very least. In more extreme situations, such as the Flash Crash, HFT can be highly destabilizing as it propagates shocks across markets at very high speed."
Benos, Sagade, "High-frequency trading behaviour and its impact on market quality: evidence from the UK equity market" (2012) Bank of England	U.K. equities, 2011 or 2012	"It thus appears that the more HFTs trade aggressively the more they contribute to both price discovery and excess volatility."

Benos, Weatherilt, " The role of designated market makers in the new trading landscape " (2012)	U.K equities	"Moreover, the de facto high-frequency market makers that have entered markets following technological advances are free to enter or exit the market at will. This allows them to compete with DMMs when market-making is profitable but withdraw altogether from the market when it is not, leaving DMMs to bear the brunt of market-making obligations in a stressed market."
Bank of England		
Biais, Foucault, " HFT and Market Quality " (2014)	Literature review	"[W]e recommend developing trading mechanisms that cater specifically to slow traders. This could require regulatory intervention to overcome exchanges' conflict of interests. We also recommend imposing minimum capital requirements for HFT firms. Moreover we emphasize the need for stress tests to evaluate the robustness of the market to technological problems or high-frequency firms' failure, and for pilot experiments, to assess and fine tune trading rules designed to slow the trading process."
Toulouse School of Economics		
Bichetti, Maystre, " The synchronized and long-lasting structural change on commodity markets: evidence from high frequency data " (2012)	U.S. futures and equities, 1997-2011	"This paper documented striking similarities in the evolution of the rolling correlations between the returns on several commodity futures and the ones on the US stock market, computed at high frequencies...we think that HFT strategies, in particular the trend-following ones, are playing a key role...commodity markets are more and more prone to events in global financial markets and likely to deviate from their fundamentals."
United Nations		
Boehmer, Fong, Wu, " International Evidence on Algorithmic Trading " (2012)	Equities in 37 countries (excluding U.S.), 2001-2009	"Overall, our results show that algorithmic trading often improves liquidity, but this effect is smaller when market making is difficult and for low-priced or high-volatility stocks. It reverses for small cap stocks, where AT is associated with a decrease in liquidity. AT usually improves efficiency. The main costs associated with AT appear to be elevated levels of volatility. This effect prevails even for large market cap, high price, or low volatility stocks, but it is more pronounced in smaller, low price, or high volatility stocks."
Singapore Management University		
Boehmer, Fong, Wu, " Algorithmic Trading and Changes in Firms' Equity Capital " (2012)	Equities in 37 countries (excluding U.S.), 2001-2009	"Our findings suggest that the activity of algorithmic traders can have impact beyond the immediate trading environment and potentially affect the more fundamental functions of capital markets, such as the allocation of capital to firms."; "We find that greater AT intensity is, on average, associated with declines in equity capital in the next year. This result is only partly driven by a decline in new securities issues; rather, greater AT intensity is associated with an increase in repurchase activity. These results control for market capitalization, book-
Singapore Management University		

to-market, volatility, liquidity, and information asymmetry at the firm level, and for secular trends at the market level..."

Boni, Brown, Leach, " Dark Pool Exclusivity Matters " (2012) University of New Mexico	U.S. equities, 2011	Excluding HFT from a market center results in lower volatility, less front-running, and higher execution quality for institutional traders.
Boulton, Braga-Alves, Kulchania, " The Flash Crash: Effects on Shareholder Wealth and Market Quality " (2012) Miami University	U.S. equities, 2010	"We show that the flash crash was not just a 20 minute glitch as it has been described in [the] popular press. Overall, the flash crash is a significant event that affected shareholder wealth, trading costs, and volatility of stocks."; "Our results suggest that seemingly fleeting events, such as the flash crash, can have dramatic and lingering effects on shareholder wealth and market quality."
Bouveret, Breuer, Chen, Jones, Sasaki, " Fragilities in the U.S. Treasury Market: Lessons from the 'Flash Rally' of October 15, 2014 " (2015) International Monetary Fund	U.S. Treasuries and futures, 2014	"Changes in the structure and functioning of Treasury markets have affected the provision of liquidity. Technological advances have made the automation of trading strategies widespread in the U.S. Treasury market, giving rise to a new breed of market makers: HFT firms. These new actors rely on small inventories to make markets and adjust their holdings rapidly in times of stress.... Measures to improve the resiliency of the U.S. Treasury market are warranted. The current frameworks for the surveillance, oversight, regulation and supervision of the Treasury markets and market participants have not kept pace with changes to market structure over recent years."
Breckenfelder, " Competition between High-Frequency Market Makers, and Market Quality " (2013) European Central Bank	Swedish equities, 2009	Examines the introduction of HFT to the Swedish market; finds evidence of HFT herding, where HFT firms take the same side of the market and increase volatility; slower traders exit the market, decreasing participant diversity; "Our findings suggest unequivocally mixed results regarding market quality. First, intraday volatility increases severely by an average of over 25%, five-minute volatility 15% and maximum intraday volatility 15%."
Brogaard, Hendershott, Hunt, Latza, Pedace, Ysusi, " High-frequency trading and the execution costs of institutional investors " (2012) University of Washington	U.K. equities, 2007-2011	HFT firms maintain they lower costs for traditional investors. This study notes that while investor costs have gone down in recent years, HFT firms don't account for those lower costs. "We show that in the UK, like in the US, there has broadly been a decrease in institutional execution costs over the last decade...[but] we fail to observe a relationship between HFT and institutional execution costs."

<p>Brogaard, Hendershott, Riordan, "High Frequency Trading and the 2008 Short Sale Ban" (2015)</p>	<p>U.S. equities, 2008</p>	<p>"Overall HFTs' trading and HFTs' short selling decreases liquidity by adversely selecting liquidity suppliers....Hence, a conservative interpretation of the results is that a component of HFTs' activity that is harmful. Consistent with a number of theoretical papers, the results suggest that a policy response to HFTs could include restrictions on HFTs."</p>
<p>Budish, Cramton, Shim, "The High-Frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response" (2015)</p>	<p>U.S. futures and equities, 2005-2011</p>	<p>"These arbitrage rents also induce a never-ending speed race....arbitrage rents lead to a classic prisoner's dilemma: snipers invest in speed to try to win the race to snipe stale quotes; liquidity providers invest in speed to try to get out of the way of the snipers; and all trading firms would be better off if they could collectively commit not to invest in speed, but it is in each firm's private interest to invest. Notably, competition in speed does not fix the underlying problem of mechanical arbitrages from symmetrically observed public information. The size of the arbitrage opportunity, and hence the harm to investors via reduced liquidity, depends neither on the magnitude of the speed improvements (be they milliseconds, microseconds, nanoseconds, etc.), nor on the cost of cutting edge speed technology (if speed costs get smaller over time there is simply more entry)."</p>
<p>University of Chicago</p>		<p>See also "The Big Question: Are high frequency traders ruining the market?"</p>
<p>Caivano, "The Impact of High Frequency Trading on Volatility" (2015)</p>	<p>Italian equities, 2011-2013</p>	<p>"Results show that an exogenous increase of HFT activity causes a statistically and economically significant increase in volatility."</p>
<p>CONSOB (Commissione Nazionale per le Società e la Borsa)</p>		
<p>Calcagnile, Bormetti, Treccani, Marmi, Lillo, "Collective synchronization and high frequency systemic instabilities in financial markets" (2015)</p>	<p>U.S. equities, 2001-2013</p>	<p>"Analyzing a large dataset of stocks traded on the US markets, our study evidences that since 2001 the level of synchronization of large price movements across assets has significantly increased."</p>
<p>List S.p.A.</p>		
<p>Cartea, Payne, Penalva, Tapia, "Ultra-Fast Activity and Market Quality" (2015)</p>	<p>U.S. equities, 2007-2015</p>	<p>"Overall, though, we provide consistent evidence that the order placement/cancellation strategies of some traders in US equity markets are associated with lower levels of liquidity. In contrast to earlier work on HFT, there is clearly no positive relationship between our UFA [ultra-fast activity] measure and market quality."</p>
<p>University of Oxford</p>		
<p>CBOT, CBOT-13-9358-BC</p>	<p>U.S. futures, 2012</p>	<p>"Panel found that on December 14, 2012, Credit Suisse operated an automated trading</p>

system ('ATS') that malfunctioned and caused an excessive number of orders and cancel messages to be entered in the March 2013 Two-Year futures contract on the Globex electronic trading platform. Although Credit Suisse became aware of the malfunction immediately, it allowed the ATS to continue to operate for 90 minutes while attempting to identify the cause and rectify the problem. During those 90 minutes, the ATS accounted for 88% of the messaging volume in the contract. Credit Suisse ultimately deactivated the ATS only after the Exchange contacted the firm regarding the messaging activity."

CFA Institute, " Dark Pools, Internalization, and Equity Market Quality " (2012)	U.S. equities, 2009-2011	"The results from this study suggest that if a majority of trading in a given stock takes place in undiscovered venues, spreads will likely increase and market quality will deteriorate. If the majority of order flow is filled away from pre-trade transparent markets, investors could withdraw quotes because of the reduced likelihood of those orders being filled. As investors become disincentivized from displaying orders, bid-offer spreads are likely to widen. Therefore, competition should be maintained to encourage aggressive quoting in displayed order books and a predominance of dark trading should be avoided."
Chae, Wang, " Determinants of Trading Profits: The Liquidity Provision Decision " (2009) Seoul National University	Taiwanese equities, 1997-2002	Absent mandatory obligations, market maker privileges don't induce market makers to provide liquidity; privileged but poorly regulated market makers make profits when demanding liquidity in their own informed trades; unconstrained market makers are informed traders rather than liquidity providers in most scenarios.
Chakrabarty, Jain, Shkilko, Sokolov, " Speed of market access and market quality: Evidence from the SEC naked access ban " (2014) St. Louis University	U.S. equities, 2011-2012	"Our results support the theoretical predictions that fast traders, competing for fleeting trading opportunities, adversely select liquidity providers, who in turn shift the added cost to liquidity demanders by widening spreads....Put differently, a liquidity demander who prefers to trade at efficient prices <i>and</i> at a low cost derives a net benefit from the reduced speed of market access in the wake of the ban....This study is, to the best of our knowledge, the first to test recent theories of speed competition, by examining the effects of the naked access ban, which has turned out to be a regulatory speed bump for HFT in the U.S. equity markets. As such, our results bring new evidence to the ongoing debate on restrictions to fast trading."

Chang, Liu, Suardi, Wu, " Informed High Frequency Trading with Advance Peek on Index of Consumer Sentiment " (2014)	U.S. equities, 2008-2010	"This paper provides evidence of large profits earned by informed high frequency traders (HFTs) from two seconds advance peek of Michigan Index of Consumer Sentiment (ICS)."
National Chenchu University		
China Securities Regulatory Commission, " Investigation and Penalties Regarding the Abnormal Trading of Everbright Securities " (2013)	Trading firm Chinese equities data and trading firm procedures, 2013.	"At 11:05 August 16, 2013, due to error of its ETF strategy transactions system, Everbright Securities mistakenly placed a massive RMB 23.4 billion worth of purchase orders for 180 ETF, of which RMB 7.27 billion were concluded, causing CSI300 Index, Shanghai Composite Index and other major indices and many heavyweight stocks to experience short-lived yet violent fluctuations."
Chung, Chuwongant, " Uncertainty, Fear, and Liquidity " (2012)	U.S. equities, 1997, 2001, 2007-2009	"Based on this result, we conjecture that higher volatility in asset prices and larger fluctuations in liquidity in recent years may be due, at least in part, to the reduced role of [traditional, regulated] market makers and the increased role of high-frequency traders who do not have the affirmative obligation of the traditional market makers. These findings should prove useful to market regulators who are interested in devising a more robust market structure."
State University of New York		
Clapham, Haferkorn, Zimmerman, " Does Speed Matter? The Role of High Frequency Trading for Order Book Resiliency " (2015)	German equities, 2009	"HFT and AT participants totally refrain from refitting the order book depth level. This is only achieved by human traders contributing with abnormally high net liquidity provision combined with large order sizes. Therefore, fast and transient liquidity provision of HFTs that is also prevailing after liquidity shocks, represents only a very specific and limited contribution to overall order book resiliency. In order to absorb further liquidity shocks, order book depth levels have to be refitted by manifold orders. As shown in our analysis, this is only achieved with the help of various human traders that persistently stay in the order book and offer a vast amount of non-transient liquidity."
Goethe University Frankfurt Faculty of Economics and Business Administration		
Clark-Joseph, " Exploratory Trading " (2013)	U.S. futures, 2010	"The exploratory trading model also illuminates the manner in which these HFTs benefit from low latency capabilities and from their submission of large numbers of aggressive orders. Exploratory trading is a form of costly information acquisition, albeit an unfamiliar one. HFTs who engage in exploratory trading are doing something more than merely reacting to public information sooner other market participants."
Harvard University		
		Note that access to this paper has been restricted. See " The Influence of the For Profit Exchanges ".

CME Group, " Member Update, December 2011 Volume 12 " (2011).	Trading firm U.S. futures data and trading firm procedures, 2009-2010	"The Panel concluded that by failing to diligently supervise its systems, employees or agents in the conduct of their business relating to the Exchange, Infinium violated CME Rule 432.W. The Panel further concluded that in allowing a malfunctioning ATS to operate in a live trading environment, Infinium committed an act detrimental to the welfare of the Exchange, in violation of CME Rule 432.Q."
Convergex, " European Equity Market Structure Survey " (2014)	Survey of European market participants	39% of survey respondents believed HFT was harmful or very harmful to market participants.
Convergex, " U.S. Equity Market Structure Survey " (2014)	Survey of U.S. market participants	"Our survey found that a majority of financial industry participants believe that the U.S. equity markets are unfair and that HFT is harmful."
Convergex, " U.S. Equity Market Structure 'Flashback' Survey " (2015)	Survey of U.S. market participants	57% of survey respondents believed stock markets are not fair for all participants.
Dichev, Huang, Zhou, " The Dark Side of Trading " (2011) Emory University	U.S. equities, 1926-2009	"Our main finding is that, controlling for other factors, there is a reliable and economically substantial positive relation between volume of trading and stock volatility. The conclusion is that stock trading produces its own volatility above and beyond that based on fundamentals..."; "The combined impression from these results is that stock trading injects an economically substantial layer of volatility above and beyond that based on fundamentals, especially at high levels of trading."
Ding, Hanna, Hendershott, " How Slow is the NBBO? A Comparison with Direct Exchange Feeds " (2013) Wells Fargo Bank	U.S. equities, 2012	"While price dislocations have small effects on infrequently trading investors, investors that are continuously in the market can be substantially disadvantaged."
Direct Edge, " Notice of Filing and Immediate Effectiveness of Proposed Rule Change to Offer and Establish Fees for a New Exchange Service, EdgeRisk Gateways " (2013)	U.S. equities	The EDGX Exchange, a subsidiary of Direct Edge, submitted an extraordinary filing to the SEC proposing a facility that would protect its customers from manipulative quote stuffing strategies. Fees for the service started at \$5,000/month. "In providing access to a pair of access gateways, the Service is also designed to allow Subscribers to mitigate risks associated with potentially fraudulent and manipulative acts and practices that may adversely affect the Subscriber's trading experience. If, for example, a firm attempted to manipulate the submission of order flow into shared access gateways by directly or indirectly causing a surge in message traffic to be sent to the Exchange, Subscribers would, to an extent,

mitigate the risks associated with such a manipulative tactic, as they would be insulated from all such external order flow."

Themis Trading [wrote about the service](#) on November 14, 2014, "Rather than try and identify the quote stuffing culprit, exchanges have figured out a way to profit from this illegal activity." EDGX filed to discontinue it on December 5, 2014.

Dolgopolov, "Regulating Merchants of Liquidity: Market Making from Crowded Floors to High-Frequency Trading" (2015)	Literature review	"The phenomenon of high-frequency trading ('HFT') is of particular significance for regulatory reassessment and reform of market making, as new players, high-frequency traders ('HFTs'), are often seen as another iteration of market makers. However, this multifaceted phenomenon does not always fit the traditional definition of market making, and perhaps many forms of HFT can be better analogized to older and more familiar practices of 'floor trading' and 'scalping.'"
Decimus Capital Markets		
Easley, Lopez del Prado, O'Hara, "The Microstructure of the Flash Crash" (2011)	U.S. futures, 2010	Unregulated or poorly regulated HFT market makers can exacerbate price volatility when they dump inventory and withdraw, flash crashes will recur because of structural issues.
Cornell University		
Egginton, Van Ness, Van Ness, "Quote Stuffing" (2012)	U.S. equities, 2010	"We find that quote stuffing is pervasive with several hundred events occurring each trading day and that quote stuffing impacts over 74% of US listed equities during our sample period. Our results show that, in periods of intense quoting activity, stocks experience decreased liquidity, higher trading costs, and increased short-term volatility. Our results suggest that the HFT strategy of quote stuffing may exhibit some features that are criticized in the media."
Louisiana Tech University		
Egginton, Van Ness, Van Ness, "Dealers and Changing Obligations: The Case of Stub Quoting" (2012)	U.S. equities, 2007 and 2010	"Taken together, our results suggest that restrictions on stub quoting, which increase dealers' obligations to quote near the NBBO, may benefit financial markets in that it encourages dealers to provide liquidity."
Louisiana Tech University		
Ferguson, Mann, "Execution Costs and Their Intraday Variation in Futures Markets" (2001)	U.S. futures, 1992	Unregulated or poorly regulated market makers in the futures market have much more rapid inventory cycles than (regulated) equity market makers, are active rather than passive traders, and "actively trade for their own accounts, profiting from their privileged access..."
University of Cincinnati		
Filimonov, Bicchetti, Maystre, Sornette, "Quantification of the High Level of Endogeneity and of Structural Regime Shifts in Commodity Markets" (2013)	U.S. and European futures, 1998-2012	"For all analyzed markets, we have found high levels of endogeneity. On average, our conservative estimates show that more than one out of two price changes is due to

another preceding price change since the second-half of the 2000s, and not due to an exogenous piece of news. In other words, price dynamics on these commodity markets are partly driven by self-reinforcing mechanisms. In our view, this evolution partly reflects the development of algorithmic trading and of high frequency trading in particular."

<p>FINRA, "Financial Industry Regulatory Authority Letter of Acceptance, Waiver and Consent No.20090186944" (2013)</p>	<p>U.S. data and broker firm procedures, 2008-2011</p>	<p>"During the period of January 2008 through December 2011 (the 'relevant period'), the Firm failed to establish, maintain and enforce adequate supervisory systems and procedures, including written supervisory procedures that were reasonably designed to achieve compliance with applicable securities laws and regulations, including FINRA and exchange rules, addressing anti-money laundering and other potentially manipulative and suspicious trading activity by the Firm's DMA and SA clients, such as spoofing, marking the close, excessive repetitive order entry, and wash sale transactions, numerous instances of which may have occurred on as many as four exchanges."</p>
<p>FINRA, "Financial Industry Regulatory Authority Letter of Acceptance, Waiver and Consent No.2010022334505" (2014)</p>	<p>U.S. equities, 2010-2013</p>	<p>"This matter involves CDRG's failure to reasonably prevent the transmission of erroneous orders to Nasdaq, BATS Exchange, Inc. ('BZX'), BATS Y-Exchange, Inc. ('BYX'), and NYSE Arca, Inc. ('NYSE Arca') (the 'exchanges') during the period March 18, 2010 through January 8, 2013 ('review period')."</p>
<p>FINRA, "FINRA Charges Wedbush Securities for Systemic Market Access Violations, Anti-Money Laundering and Supervisory Deficiencies" (2014)</p>	<p>U.S. data and broker firm procedures, 2008-2013</p>	<p>"The complaint alleges that from January 2008 through August 2013, Wedbush failed to dedicate sufficient resources to ensure appropriate risk management controls and supervisory systems and procedures. This enabled its market access customers to flood U.S. exchanges with thousands of potentially manipulative wash trades and other potentially manipulative trades, including manipulative layering and spoofing."</p> <p>From the complaint:</p> <p>"During the relevant period, Wedbush executed for market access customers over 100,000 instances of potential layering, spoofing and auto-execution manipulation, executed in multiple securities across the Exchanges. Wedbush's high-volume, high-frequency trading customers employed aggressive, potentially destabilizing trading strategies in illiquid securities."</p>

Frino, Forrest, Duffy, " Life in the pits: competitive market making and inventory control-further Australian evidence " (1999)	Australian futures, 1997	Unregulated or poorly regulated market makers are not passive liquidity providers, they behave aggressively like informed traders.
University of Sydney		
Frino, Jarnecic, " An empirical analysis of the supply of liquidity by locals in futures markets: Evidence from the Sydney Futures Exchange " (2000)	Australian futures, 1997	Unregulated or poorly regulated market makers demand liquidity to profit from information advantages of privileged access, less likely to supply liquidity in volatile markets, almost as likely to demand as to supply liquidity.
University of Sydney		
Frino, Jarnecic, Feletto, " Local Trader Profitability in Futures Markets: Liquidity and Position Taking Profits " (2009)	Australian futures, 1997	Unregulated or poorly regulated market makers are active and informed traders.
University of Sydney		
Gao, Mizrach, " High Frequency Trading in the Equity Markets During U.S. Treasury POMO " (2013)	U.S. equities, 2008-2009	"While HFT firms are generally deemed to be passive liquidity providers, we find that they act as trade initiators in nearly 47% of trades in normal times. High frequency traders appear to have superior information. Whether they are at the active or passive side, the trades are more profitable when the counterpart is a non-HFT firm rather than a HFT firm. The 'Flash Crash' helps to clarify why reporting the average effect of HFT firms on the market may provide a misleading portrait of their contribution to market quality. Analyzing their impact when the market is under stress or reacting to news needs to be isolated from their contribution during less turbulent periods."
Rutgers University		
Gao, Mizrach, Ozturk, " Quote Stuffing and Market Quality " (2015)	U.S. equities, 2008-2013	"Rapid submission and cancellation strategies by high-frequency trading (HFT) firms are a common occurrence, affecting hundreds of ticker symbols every day. We find that quote stuffing is harmful to market quality: prices become more volatile and bid-ask spreads rise. This occurs not only on the Nasdaq where we observe the quote stuffing, but also on the NYSE, Archipelago and Amex. HFT quote stuffing raises their market share of trading activity."
Rutgers University		
Gerig, " High-Frequency Trading Synchronizes Prices in Financial Markets " (2015)	U.S. equities, 2000, 2005, 2010	"Policy makers across the globe are spending considerable effort deciding if and how to regulate HFT. On the one hand, HFT appears to make markets more efficient. Algorithmic trading in general, and HFT specifically, increases the accuracy of prices and lowers transaction costs. On the other hand, HFT appears to make the financial system as a whole more fragile. The rapid fall and subsequent rise in prices that occurred in US markets on May 6, 2010 (known as the 'Flash Crash'), was, in part, due to
U.S. Securities and Exchange Commission		

		HFT....during times of market stress, HFT firms are impelled to leave the market if their systems observe events outside the parameters they are programmed to handle - a circumstance that causes liquidity to disappear at the precise time it is needed the most."
Golub, Keane, " Mini Flash Crashes " (2011) Manchester Business School	U.S. equities, 2006-2010	"As soon as the [HFT] market maker's risk management limits are breached...the market maker has to stop providing liquidity and start to aggressively take liquidity, by selling back the shares bought moments earlier. This way they push the price further down and thus exaggerate the downward movement."
Golub, Keane, Poon, " High Frequency Trading and Mini Flash Crashes " (2012) Manchester Business School	U.S. equities, 2006-2011	"We find strong evidence that Mini Flash Crashes have an adverse impact on market liquidity and are associated with Fleeting Liquidity."; "Given the speed and the magnitude of the crashes, it appears likely that Mini Flash Crashes are caused by HFT activity."
Government Office for Science, " Foresight: The Future of Computer Trading in Financial Markets, Final Project Report: Executive Summary " (2012)	Varied data; literature reviews	"A key message: despite commonly held negative perceptions, the available evidence indicates that high frequency trading (HFT) and algorithmic trading (AT) may have several beneficial effects on markets. However, HFT/AT may cause instabilities in financial markets in specific circumstances."
Hasbrouck, " High frequency quoting: Short-term volatility in bids and offers " (2015) New York University	U.S. equities, 2001-2011	"As defined and estimated here, quote volatility reflects both fundamental and transient volatility. These two components are not resolved, but variance ratios can be used to infer their relative magnitudes. These estimates suggest that at sub-second time scales, variance is generally more than double the level that would be implied by a relatively long-term (twenty-minute) variance that is presumably more fundamental."
Hautsch, Huang, " On the Dark Side of the Market: Identifying and Analyzing Hidden Order Placements " (2012) University of Vienna	U.S. equities, 2010	A frequent criticism of the proprietary data feeds exchanges sell to HFT firms is that the feeds reveal information investors reasonably believe is confidential; "Using data from the NASDAQ TotalView message stream allows us to retrieve information on hidden depth from one of the largest equity markets in the world."
Hirschey, " Do High-Frequency Traders Anticipate Buying and Selling Pressure? " (2013) London Business School	U.S. equities, 2009	"I find evidence consistent with HFTs being able to anticipate order flow from other investors."; "These findings provide evidence supporting the existence of an anticipatory trading channel through which HFTs may increase non-HFT trading costs."

<p>Hong Kong Securities and Futures Commission, "SFC reprimands and fines IMC Asia Pacific Limited [HK]\$1.5 Million" (2012)</p>	<p>Trading firm Hong Kong data and trading firm controls, 2007-2010</p>	<p>"IMC's failures spanned a period of over three years during a time of substantial market volatility when short selling controls were high on the regulatory agenda. IMC's negligent controls were well below the standards expected in Hong Kong. Market participants should be aware that short selling is tightly regulated in Hong Kong and any breaches of the rules will be strictly enforced,' the SFC's Executive Director of Enforcement, Mr Mark Steward said."</p>
<p>Huh, "Machines vs. Machines: High Frequency Trading and Hard Information" (2014)</p> <p>U.S. Federal Reserve Bank</p>	<p>U.S. equities, 2008</p>	<p>"A major concern about HFTs replacing traditional market makers is that since HFTs do not have market making obligations, they might leave the market when market makers are needed the most. Although my sample period does not cover certain extreme events such as the 2010 Flash Crash (the market turmoil in 2008 is arguably quite extreme as well, albeit in a different way), I do document that the market-making HFTs provide less liquidity replenishment when markets are volatile."</p>
<p>International Monetary Fund, "Global Financial Stability Report" (2015)</p>	<p>Literature review</p>	<p>"[E]lectronic trading platforms can also facilitate the growth of high-frequency trading (HFT) firms, with a potential negative impact on the resilience of liquidity. These firms are thought to have been one of the causes of the October 2014 flash rally episode in the U.S. Treasury market. Events such as this, and the May 6, 2010, flash crash in U.S. equity and equity futures markets, show how liquidity can evaporate very quickly even on the most liquid markets in the world and how the lack of liquidity can amplify shocks, resulting in heightened levels of volatility."</p>
<p>Jiang, Lo, Valente, "High-Frequency Trading around Macroeconomic News Announcements: Evidence from the U.S. Treasury Market" (2014)</p> <p>Washington State University</p>	<p>U.S. Treasuries, 2006-2011</p>	<p>"We find that an abnormal increase in HF activities leads to a significant increase in spreads preceding macroeconomic news announcements. The positive impact on spreads mainly comes from HF trades. Following the announcements...HF activities have a negative impact on liquidity upon public information arrival. Overall HF activities significantly reduces depth both at the best quotes and behind the best quotes."</p>
<p>Johnson, Zhao, Hunsader, Qi, Johnson, Meng, Tivnan, "Abrupt rise of new machine ecology beyond human response time" (2013)</p> <p>University of Miami</p>	<p>U.S. equities, 2006-2011</p>	<p>"In this paper we carry out a study of ultrafast extreme events (UEEs) in financial market stock prices. Our study is inspired by the seminal works of Farmer, Preis, Stanley, Easley and Cliff and co-workers who stressed the need to understand ultrafast market dynamics. To carry out this research, we assembled a high-throughput millisecond-resolution price stream across multiple stocks</p>

and exchanges using the NANEX NxCore software package. We uncovered an explosion of UEEs starting in 2006, just after new legislation came into force that made high frequency trading more attractive. Specifically, our resulting dataset comprises 18,520 UEEs (January 3rd 2006 to February 3rd 2011) which are also shown visually on the NANEX website at www.nanex.net."

<p>Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues, "Recommendations Regarding Regulatory Responses to the Market Events of May 6, 2010" (2011)</p>	<p>U.S. futures and equities, 2010</p>	<p>"In the present environment, where high frequency and algorithmic trading predominate and where exchange competition has essentially eliminated rule-based market maker obligations, liquidity problems are an inherent difficulty that must be addressed. Indeed, even in the absence of extraordinary market events, limit order books can quickly empty and prices can crash simply due to the speed and numbers of orders flowing into the market and due to the ability to instantly cancel orders."</p>
<p>Jorgensen, Skjeltorp, Ødegaard, "Throttling Hyperactive Robots - Message to Trade Ratios on the Oslo Stock Exchange" (2014) BI Norwegian Business School</p>	<p>Norwegian equities, 1999-2012</p>	<p>"We use the introduction of a cost on high message to trade ratios for traders at the Oslo Stock Exchange to investigate the effects on market quality and fragmentation of introduction of such 'speed bumps' to equity trading. The exchange introduced a fee payable by market participants whose orders (messages to the exchange's trade system) exceeded seventy times the number of consummated trades. Market participants quickly adjusted their behavior to avoid paying the extra cost. The overall ratios of messages to trades fell, but common measures of the quality of trading, such as liquidity, transaction costs, and realized volatility, did not deteriorate, they were essentially unchanged."</p>
<p>Kang, Shin, "The Role of High Frequency Traders in Electronic Limit Order Markets" (2012) KAIST (Korea Advanced Institute of Science and Technology)</p>	<p>Korea futures, 2007</p>	<p>"We find that when high frequency traders make use of fleeting orders actively, the level of informativeness in the limit order book declines. This evidence suggests, albeit indirectly, that massive use of limit orders including revision and cancellation by high frequency traders may potentially have negative effects on the market."</p>
<p>Kim, Murphy, "The Impact of High-Frequency Trading on Stock Market Liquidity Measures" (2013) Northwestern University</p>	<p>U.S. equities, 1997-2009</p>	<p>Traditional market microstructure models have significantly underestimated market spreads in recent years. This is because of how trade sizes have decreased with the recent dominance of high frequency trading. When the authors correct for this they find that spreads have not decreased as much as HFT proponents believe. "[I]ncreased high-frequency trading may not</p>

necessarily be associated with improved liquidity."

Kirilenko, Lo, " Moore's Law vs. Murphy's Law: Algorithmic Trading and Its Discontents " (2013)	Literature review	"In contrast to a number of public claims, high frequency traders do not as a rule engage in the provision of liquidity like traditional market makers. In fact, those that do not provide liquidity are the most profitable and their profits increase with the degree of 'aggressive,' liquidity-taking activity."
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Kirilenko, Samadi, Kyle, Tuzun, " The Flash Crash: The Impact of High Frequency Trading on an Electronic Market " (2014)	U.S. futures, 2010	Unregulated or poorly regulated HFT market makers exacerbated price volatility in the Flash Crash, hot potato trading, two minute market maker inventory half-life; "These results are inconsistent with the notion that High Frequency Traders behave like textbook market makers, suffering adverse selection losses associated with being picked off by informed traders. Instead, when the price is about to move to a new level, HFTs tend to avoid being run over and take the price to the new level with Aggressive trades of their own....At times of market stress, when prices are moving directionally, due to an order flow imbalance and the volatility is already elevated, this trading activity can amplify a directional price move and significantly add to volatility."
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Korajczyk, Murphy, " High Frequency Market Making to Large Institutional Trades " (2015)	Canadian equities, 2012-2013	"[I]t is possible that an HFT 'frontruns' these large orders, in that the HFT buys (sells) ahead of a large stressful buy (sell) and subsequently sells to (buys from) the large trader at a higher (lower) price we find that HFT activity is higher during the beginning and end of any large buy—it is likely higher during the beginning because the HFT has not completely inferred yet that a large trade with potential price impact is underway, while it is likely higher during the end because HFTs have previously pulled back their sell orders (or aggressively bought the shares contained in other traders' sell orders) and are now offering the same shares through passive orders."
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Kurov, Lasser, " Price Dynamics in the Regular and E-Mini Futures Markets " (2004)	U.S. futures, 2001	Unregulated or poorly regulated market makers demand liquidity to profit from information advantages of privileged access.
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Kwan, Philip, " High frequency trading and execution costs " (2015)	Australian equities, 2011-2012	"We examine whether high-frequency traders (HFT) increase the transaction costs of slower institutional and retail traders (non-HFT)...we find that limit order trading costs for non-HFT increase relative to the costs for HFT. We attribute the increase in non-HFT execution costs to more predatory trading by

HFT. After the implementation of ITCH, we show that HFT are more successful in front-running non-HFT limit orders, which decreases the execution probability of non-HFT limit orders."

See also ["High-frequency trading and dark pools: a toxic effect on market evolution?"](#)

Lee, "High Frequency Trading in the Korean Index Futures Market" (2013)	Korean futures, 2009-2010	"We find that high frequency traders (HFTs) do not provide liquidity in the futures market, nor does HFT have any role in enhancing market quality. Indeed, HFT is detrimental to the price discovery process."
Hanyang University		
Linton, O'Hara, "The impact of computer trading on liquidity, price efficiency/discovery and transaction costs" (2011)	Literature review	"The nature of market making has changed, shifting from designated providers to opportunistic traders. High frequency traders now provide the bulk of liquidity, but their use of limited capital combined with ultra-fast speed creates the potential for periodic illiquidity"; in "regular market conditions," liquidity has improved and transaction costs are lower.
Cambridge University		
Locke, Sarajoti, "Interdealer Trading in Futures Markets" (2001)	U.S. futures, 1995	Unregulated or poorly regulated market makers demand liquidity to manage inventories.
Texas Christian Univerisity		
Lyons, "A Simultaneous Trade Model of the Foreign Exchange Hot Potato" (1997)	Model derived from empirical studies of 1992 U.S. foreign exchange market.	Demonstrates hot potato trading among unregulated or poorly regulated market makers. "Hot potato trading" means cascading inventory imbalances from market maker to market maker in response to a large order. Hot potato trading explains most of the volume in foreign exchange markets. Hot potato trading is not innocuous - it makes prices less informative.
University of California		
See also Kirilenko, Samadi, Kyle, Tuzun, "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market" .		
Lyons, "Foreign exchange volume: Sound and fury signifying nothing?" (1996)	U.S. foreign exchange, 1992	Unregulated or poorly regulated market makers cascade inventory imbalances from one to another, as "...trading begets trading. The trading begotten is relatively uninformative, arising from repeated passage of inventory imbalances among dealers...this could not arise under a specialist [regulated market maker] microstructure."
University of California		
See also Kirilenko, Samadi, Kyle, Tuzun, "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market" .		
Machain, Dufour, "The Price Impact of Limit	U.K. equities	"[P]olicy makers have recently suggested the

[Order Cancellations](#)" (2013)

University of Reading

introduction of a minimum period of time a limit order should be kept on the order book to avoid speculative practices. In this paper, we provide empirical evidence supporting that."

MacKenzie, "[A Sociology of Algorithms: High Frequency Trading and the Shaping of Markets](#)" (2014)

University of Edinburgh

HFT practitioner interviews

"Unexpected behavior by trading algorithms has led to well publicized disasters, such as the \$440 million loss incurred in 45 minutes by Knight Capital on August 1, 2012 when an old, forgotten algorithm mistakenly left on one of Knight's trading servers suddenly sprung to life. Indeed, human users of algorithms may not always accurately understand even their routine behavior:

[S]omeone could be in all honesty saying [their algorithms are] doing [something] when in fact they are doing something else: they're just not measuring it right. (Interviewee AP)"

See also "[Be Grateful for Drizzle](#)".

Malinova, Park, "[Liquidity Provision and Market Making by HFTs](#)" (2015)

University of Toronto

Canadian equities, 2013

"In this report we describe and analyze the market-making behaviour of high frequency traders. We describe how high-frequency market makers submit quotes relative to posted prices, and we analyze how market makers react to trades by canceling their existing quotes and by eliminating others' stale quotes with aggressive, marketable orders....Overall, our analysis indicates that after, say, trading with a buyer, market-makers cancel their sell orders quickly and submit aggressive buy orders. This latter behavior can be interpreted as market makers either trading in anticipation of future orders or taking advantage of and eliminating mis-priced, stale quotes."

Madhavan, "[Exchange-Traded Funds, Market Structure and the Flash Crash](#)" (2011)

Blackrock

U.S. equities, 1994-2011

"We show that the impact of the Flash Crash across stocks is systematically related to prior market fragmentation."; "Using intraday trade data from January 1994-September 2011, we find that fragmentation now is at the highest level recorded."; "The link to higher frequency quotation activity and the current high levels of fragmentation help explain why a Flash Crash did not occur before and offers a counterpoint to the view that the Flash Crash stemmed from an unlikely confluence of events."

Manaster, Mann, "[Life in the pits: competitive market making and inventory control](#)" (1996)

University of Utah

U.S. futures, 1992

Unregulated or poorly regulated market makers aggressively manage inventory, are "active profit-seeking," have much shorter inventory cycles than then-regulated equities market makers.

Manaster, Mann, " Sources of Market Making Profits: Man Does Not Live by Spread Alone " (1999) University of Utah	U.S. futures, 1992	Unregulated or poorly regulated market makers demand liquidity to profit from information advantages of privileged access, are "predominant" informed traders.
McInish, Upson " Strategic Liquidity Supply in a Market with Fast and Slow Traders " (2012) University of Memphis	U.S. equities, 2008	"We 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."; "[O]ur research focuses on the ability of fast liquidity suppliers to use their speed advantage to the detriment of slow liquidity demanders, which we believe unambiguously lowers market quality. The ability of fast traders to take advantage of slow traders is exacerbated in the U.S. by the regulatory and market environment that we describe below."
Menkveld, Yueshen, " The Flash Crash: A Cautionary Tale about Highly Fragmented Markets " (2015) VU University Amsterdam	U.S. futures and equities, 2010	An independent study confirming Kirilenko's findings that high frequency traders exacerbated volatility and caused significant price declines in the Flash Crash; "There is widespread concern that Flash Crash type events are the result of vulnerable electronic markets....the costs arising from broken markets are borne by end-users of securities markets. The Flash Crash was by no means unique. Similar crashes hit the German DAX index (August 18, 2011 and April 17, 2013), the oil price (May 5, 2011), India's National Stock Exchange index (October 5, 2012), the Anadarko stock (May 20, 2013), and the Procter and Gamble stock (August 30, 2013)."
Menkveld, Zoican, " Need for Speed? Exchange Latency and Liquidity " (2014) VU University Amsterdam	Danish, Swedish, and Finnish equities, 2009-2010	"The paper's findings contribute to the public debate on electronic markets and, in particular, the role of speed in the trading process. It adds the insight that a faster market implies more interaction among HFTs, i.e., their market participation increases and, more importantly, transaction cost for 'low frequency' investors increases as a result."
Nanex, " Ongoing Research - Market Events and Phenomena " and " Research Pages " (2010-2016)	U.S. options, futures, and equities, 2006-2016	Nanex has prepared some of the most compelling - and disturbing - evidence-driven analyses of U.S. capital market events and dislocations publicly available. See also the following CNBC reports " News organizations respond to Fed lockup questions. ", " Unraveling Monday's Early Data Release to Traders. " and " Thomson Reuters Gives Elite Traders Early Advantage. "
Nanex, " Latency on Demand? " (2010)	U.S. equities, 2010	One of the analyses that earned Nanex founder Eric Hunsader a whistleblower award from the SEC , and the first of its kind; "We

wanted to see the extent of the delay between NYSE quotes from CQS and OpenBook on a more recent trading day. So we synchronized quotes from CQS and OpenBook for GE between 1pm and 4pm Eastern time and plotted 30 minutes worth of timestamp differences along with the quote price which are shown in Chart 1 below. We were surprised to see the frequency and magnitude of the delay. We thought high quote activity in a stock would cause a delay in that stock's quote, but could not find any correlation between the quote activity in GE and the delay."

Nanex, "Perfect Pilfering" (2014)	U.S. equities, 2014.	"The chart on the right clearly shows that order cancellations happen far faster than trade executions (red line goes up faster than blue line). This is why our trader wasn't able to get the advertised liquidity - those sell orders simply disappeared before the exchanges processed his buy order."
See also "Self-Regulatory Organizations; The NASDAQ Stock Market LLC; Notice of Filing of Proposed Rules Change to Amend Rule 4758(a)(1)(A) to Reflect a Change in Nasdaq's Routing Functionality"		
Nasdaq, "Notice of Acceptance of Letter of Acceptance, Waiver and Consent No. 20100214899-02" (2013)	Trading firm U.S. data and trading firm procedures, 2009-2011.	"During the review period, IMCC failed to establish and maintain adequate supervisory procedures, and a reasonable system of follow-up and review, related to the oversight of the firm's high frequency and algorithmic trading, including procedures related to the review of wash sales, levels of message traffic and quotes, potentially erroneous trading activity, or the filing of Clearly Erroneous Execution ('CEE') petitions."
Nasdaq, "Notice of Acceptance of Letter of Acceptance, Waiver and Consent No. 20100242271-01" (2012)	Trading firm U.S. data and trading firm procedures, 2010-2011.	"During the review period, the firm failed to establish and maintain a reasonable supervisory system, including but not limited to its written supervisory procedures and supervisory and operational risk controls systems related to the oversight and operation of high frequency trading and algorithmic trading."
Nasdaq, "Self-Regulatory Organizations; The NASDAQ Stock Market LLC; Notice of Filing of Proposed Rules Change to Amend Rule 4758(a)(1)(A) to Reflect a Change in Nasdaq's Routing Functionality" (2012)	U.S. equities	A remarkable statement by an exchange that quotes posted on US exchanges are often fleeting and inaccessible, resulting in inferior prices for investors; "NASDAQ has observed that upon partial execution of a routable order at NASDAQ...market participants often react to the order by cancelling their orders on other markets and entering new orders at inferior prices. This occurs because the current process directs the order to NASDAQ before attempting to access available liquidity

at other markets and thereby allows market participants to react to the execution (an effect known as 'market impact' or 'information leakage'). As a consequence, the available shares at the away market are no longer available, resulting in a lower likelihood of successfully accessing liquidity on away markets (i.e., the 'fill rate') and an increased likelihood of ultimately receiving an execution at an inferior price."

See also Van Kervel, "[Market Fragmentation and Smart Order Routing Technology](#)"

Norges Bank Investment Management, " High Frequency Trading - An Asset Manager's Perspective " (2013)	Literature review	With nearly \$1 trillion under management, NBIM is the world's largest sovereign wealth fund. "In our view, issues of concern to large, long-term investors more deserving of attention include — Anticipation of large orders by some HFTs leading to potential adverse market impact — Transient liquidity due to high propensity for HFTs to rapidly cancel quotes real-time — Un-level playing field amongst market makers from low latency ultra HFT strategies."
See also " Wealth Fund Cautions Against Costs Exacted by High-Speed Trading ," (NY Times, October 20, 2013) and " Role of Exchanges in Well-Functioning Markets " (NBIM, August 6, 2015)		
NYSE Arca, " Proceeding No. 20110304774 " (2014)	U.S. equities, 2010-2013	"Violated NYSE Arca Equities Rule 7.23, by failing to maintain continuous, two-sided trading interest in approximately 20,000 instances; and violated NYSE Arca Equities Rules 6.18(b) and (c), by failing to reasonably supervise the activities of its associated persons and the operation of its business in that it failed to establish and maintain adequate supervisory procedures, including written procedures, and a reasonable system of follow-up and review, reasonably designed to ensure compliance with NYSE Arca Equities Rule 7.23."
NYSE, " The New York Stock Exchange LLC Letter of Acceptance, Waiver and Consent No. 20120327307-01 " (2014)	U.S. equities, 2010-2013	"During the Relevant Period, several million SLP orders the firm entered through its SLP algorithms resulted in executions on the NYSE against other orders it entered by other of its SLP algorithms."
Panayides, " Affirmative obligations and market making with inventory " (2007)	U.S. equities, 1991 and 2001	Mandatory market maker obligations reduce volatility.
University of Utah		
Partington, Kwan, Philip, " Is High Frequency Trading Beneficial to Market Quality? " (2015)	Australian equities, 2009-2013	"This paper presents new metrics for market 'quality', which suggests that with the growth in HFT the probability of institutions getting

University of Sydney

orders filled has fallen and the time required to achieve a fill has increased."

See also "[Is High Frequency Trading Good For Capital Markets?](#)" on the Columbia University Law School's blog on corporations and the capital markets.

Pasquale, "[Law's Acceleration of Finance: Redefining the Problem of High-Frequency Trading](#)" (2015)

Literature review

"High-frequency traders automate stock trading, placing thousands of orders over fractions of a second. Their algorithmic strategies are all too often mere rule manipulation or methods of using brute speed to gain advantages over rivals. Normative evaluation of finance's algorithms must take into account the sector's social function: to spur efficient, fair, and sustainable investment practices. The complex modeling deployed in high-frequency trading does not reliably contribute to these goals. Therefore, rather than straining to accommodate high-frequency trading strategies, regulators should eliminate many of them."

University of Maryland Law School

Pragma Securities, "[HFT and the Hidden Cost of Deep Liquidity](#)" (2012)

US equities, 2011 and 2012

"In this essay we present evidence that high-frequency traders' profits come at the expense of investors. In competing to earn spreads and exchange rebates by posting passive orders, HFTs crowd out directional traders' passive orders, force them to cross the spread more often, all of which results in higher trading costs for investors."

Principal Global Investors, "Investing in a High-Frequency Trading Environment" (2014)

Survey of asset managers in 30 countries with \$6 trillion under management.

"According to proponents of HFT, it provides liquidity, keeps down trading costs, assists price discovery, and performs the market-making function. Their opponents — the majority — disagree. To them, HFT is all about front-running the trades and profiting from inter-exchange price arbitrage. It has nothing to do with market making. Indeed when markets turn volatile, high-frequency traders are usually the first to cancel their orders and rush for the exit. They do not have the affirmative obligation of usual market makers, who step in as the 'buyer or seller of last resort' in good times and bad."

Quantitative Services Group, "Liquidity Change and Price Reversals: Is High Frequency Trading Adding Insult to Injury?" (2010)

U.S. equities, 2008-2009

"Changes in the microstructure of equity markets and the emergence of HFT competitors have changed the nature and magnitude of transaction costs. Sophisticated pattern recognition algorithms now present a real return burden to active equity managers."; "Order anticipation strategies have long been a feature of equity markets. What have changed are the technology-fueled enhancements for improved pattern recognition, speed of

execution and breadth of coverage... The complexity of these interrelationships and their close proximity to legitimate market making activities will be a challenge for regulators to grapple with."

Raman, Robe, Yadav, "[Electronic Market Makers, Trader Anonymity and Market Fragility](#)" (2014)

University of Warwick

U.S. futures, 2006, 2008, 2011

"We document results of considerable academic and regulatory importance. We find strong evidence that, in sharp contrast to the erstwhile locals in futures pits, electronic market makers reduce their participation and their liquidity provision in periods of significantly high and persistent volatility, in periods of significantly high and persistent customer order imbalances, and in periods of significantly high and persistent bid ask spreads....our results raise the question of whether exchanges and regulators should consider affirmative obligations for hitherto voluntary market makers."

Rogers, Skinner, Zechman, "[Run Edgar Run: SEC Dissemination in a High-Frequency World](#)" (2015)

University of Colorado

U.S. SEC filings, 2012-2013

"[W]e also show that PDS subscribers, who pay for direct access to EDGAR, receive filings before they are available on the SEC website more than half of the time (in 57% of cases for insider purchases and in 56% of cases for insider sales). The average period of private advantage is about 10 seconds for the full sample and 18 seconds for the subsample of filings where the advantage exists, a relatively long time in the world of high frequency trading. We report clear evidence—from prices, trading volume, and spreads—that the market responds to the news in advance of its public release. All three measures of market activity begin to move up to 30 seconds before the filing is made available on the SEC site. This is hard to reconcile with the notion that the EDGAR process provides a level playing field to investors."

Saglam, "[The Rogue Algorithm and its Discontents](#)" (2015)

University of Cincinnati

U.S. equities, 2012

"I examine the impact of an exogenous trading glitch in a high-frequency market-making firm on institutional trading costs.... I find that executing a large order on a glitch-affected stock incurs substantially higher costs on the event day. Moreover, the cost increase is persistent up to one week roughly with the same additional cost magnifying the total economic costs. These findings can be interpreted as negative externalities of algorithmic trading which has important policy implications."

Schroder Investment Management Limited, "[High frequency trading: Credible research tells the story](#)" (2011)

Literature review

"As standards in research continue to improve, simple default commentary such as HFT are 'liquidity providers,' HFT 'dampens volatility' and HFT 'decreases bid-ask spreads' have suffered something of a

credibility anorexia despite their continued use by some."

<p>Senior Supervisors Group, "Algorithmic Trading Briefing Note" (2015)</p>	<p>Literature review, enforcement proceedings, and participant interviews.</p>	<p>"Indeed, unexpected events linked to algorithmic and high frequency trading have caused significant volatility and market disruption, leading to heightened debate around the risks these activities pose to the functioning of global markets. The complexity of market interactions among HFT firms and other market participants increases the potential for systemic risk to propagate across venues and asset classes over very short periods of time."</p>
<p>"The Senior Supervisors Group (SSG) is composed of the staff of supervisory agencies from ten countries and the European Union: the Canadian Office of the Superintendent of Financial Institutions, the European Central Bank Banking Supervision, the French Prudential Control and Resolution Authority, the German Federal Financial Supervisory Authority, the Bank of Italy, the Japanese Financial Services Agency, the Netherlands Bank, the Bank of Spain, the Swiss Financial Market Supervisory Authority, the United Kingdom's Prudential Regulatory Authority, and, in the United States, the Office of the Comptroller of the Currency, the Securities and Exchange Commission, and the Federal Reserve."</p>		
<p>Silber, "Marketmaker Behavior in an Auction Market: An Analysis of Scalpers in Futures Markets", (1984)</p>	<p>U.S. futures, 1982-1983</p>	<p>Unregulated or poorly regulated market makers profit from the information advantages of privileged access, two minute inventory cycles.</p>
<p>New York University</p>		
<p>Smidt, "Trading Floor Practices on Futures and Securities Exchanges: Economics, Regulation, and Policy Issues" (1985)</p>	<p>Literature review</p>	<p>On futures exchanges, inventory imbalances among unregulated or poorly regulated market makers create "potentially unstable" markets and price overreactions during "scalper inventory liquidation."</p>
<p>Cornell University</p>		
<p>Sornette, Von der Becke, "Crashes and High Frequency Trading" (2011)</p>	<p>Literature review</p>	<p>"We question in particular the argument that HFT provides liquidity and suggest that the welfare gains derived from HFT are minimal and perhaps even largely negative on a long-term investment horizon."</p>
<p>Swiss Finance Institute</p>		
<p>Tong, "A Blessing or a Curse? The Impact of High Frequency Trading on Institutional Investors" (2013)</p>	<p>U.S. equities, 2008-2009</p>	<p>"I find strong evidence that HFT increases the trading costs of institutional investors."</p>
<p>Fordham University</p>		
<p>Toulson, "Do HFTs really 'Game' buy-side orders" (2013)</p>	<p>European equities, 2013</p>	<p>"HFT liquidity providers, reacting to these trades, immediately cancelled most of the orders resting on XSTO....Other HFT market participants (not necessarily the same firms) aggressively traded 'in front' of the SOR slice....What does this example tell us? Firstly, it illustrates the degree to which liquidity and trading really do react at millisecond timescales. Buy-Side orders attempting to access such liquidity must be precise in their timing and sequencing otherwise they may be 'gamed'."</p>
<p>IFS</p>		
<p>Tse, Lin, Vincent, "High Frequency Trading - Measurement, Detection and Response" (2012)</p>	<p>European equities, 2010-2012</p>	<p>"We present a detailed study of a variety of negative HFT strategies - including examples of Quote Stuffing, Layering/Order Book Fade,</p>

Credit Suisse

and Momentum Ignition - to demonstrate what bad HFT 'looks like', how often it happens, and how we detect it."

See also "[From High Frequency Trading To A Broken Market: A Primer In Two Parts](#)".

Turbeville, " High Frequency Trading " (2013) Demos	Literature review	"[T]he illusion of market liquidity provided by HFT volume leads to the inherent instability of market pricing mechanisms. In addition, aggressive HFT tactics mislead market participants in terms fundamental price. Finally, Dark Pools, trading venues that exist because of HFTs, impair price discovery."
United States of America, " Indictment, United States v. Coscia, No. 14-CR-00551 " (2014)	U.S. futures, 2011	"It was part of the scheme that, in and around August 2011, COSCIA devised, implemented, and executed a high-frequency trading strategy in which he entered large-volume orders that he intended to immediately cancel before they could be filled by other traders. COSCIA devised this strategy to create a false impression regarding the number of contracts available in the market, and to fraudulently induce other market participants to react to the deceptive market information that he created."
United States Commodity Futures Trading Commission, " CFTC Orders Panther Energy Trading LLC and its Principal Michael J. Coscia to Pay \$2.8 Million and Bans Them from Trading for One Year, for Spoofing in Numerous Commodity Futures Contracts " (2013)	U.S. futures, 2011	"The U.S. Commodity Futures Trading Commission (CFTC) issued an Order today filing and simultaneously settling charges against Panther Energy Trading LLC of Red Bank, New Jersey, and Michael J. Coscia of Rumson, New Jersey, for engaging in the disruptive practice of 'spoofing' by utilizing a computer algorithm that was designed to illegally place and quickly cancel bids and offers in futures contracts."
United States Commodity Futures Trading Commission and Securities and Exchange Commission, " Findings Regarding the Market Events of May 6, 2010 " (2010)	U.S. futures and equities, 2010	"However, between 2:41 p.m. and 2:44 p.m., HFTs aggressively sold about 2,000 E-Mini contracts in order to reduce their temporary long positions. Thus, at this time, HFTs stopped providing liquidity and instead began to take liquidity. At this time, HFTs were competing with the large Fundamental Seller for the liquidity expected to be provided by Fundamental Buyers who would hold their positions, or by Opportunistic Buyers who would trade based on their ability to hedge their positions in the equity markets.... Moreover, compared to the three days prior to May 6, there was an unusually high level of "hot potato" trading volume – due to repeated buying and selling of contracts – among the HFTs, especially during the period between 2:41 p.m. and 2:45 p.m. Specifically, between 2:45:13 and 2:45:27, HFTs traded

over 27,000 contracts, which accounted for about 49 percent of the total trading volume, while buying only about 200 additional contracts net."; unregulated or poorly regulated HFT market makers exacerbated price volatility in the Flash Crash.

See also Kirilenko, Samadi, Kyle, Tuzun, "[The Flash Crash: The Impact of High Frequency Trading on an Electronic Market](#)"

United States Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, U.S. Commodity Futures Trading Commission, "[Joint Staff Report: The U.S. Treasury Market on October 15, 2014](#)" (2015)

U.S. Treasuries and futures, 2014

"[A]n algorithm-level analysis from the event window on October 15 suggests that the aggressive buying during the first part of the event window was unlikely to be hedging flows arising from such market making activities. Indeed, this analysis indicates that aggressive buyer initiated PTF [high frequency trading firm] trade flows during the first part of the event window mainly stemmed from trades that served to increase, rather than decrease, the exposures associated with pre-existing positions at the time of each trade (Figures 3.9 and 3.10). In total, the analysis suggests that multiple types of trading strategies were deployed by PTFs during the event window. Some PTF algorithms appear to explain the considerable amount of net passive market making activity that was witnessed across cash and futures over the event window and likely was an important contributing factor to the absence of price gapping despite the unprecedented large price swings. Another, and equally significant, group of PTF strategies appears to have aggressively traded in the direction of price moves during the event window, accounting for the bulk of the overall aggressive trading imbalance observed."

See also "[High-Frequency Firms Dominate Treasury Trading in Near Secret](#)," Bloomberg, September 24, 2015 and "[Speed Traders, Banks Called Out in Report on Treasury Swing](#)," Bloomberg, July 13, 2015.

United States Federal Reserve Bank of Chicago, Carol Clark, "[How to Keep Markets Safe in the Era of High-Speed Trading](#)" (2012)

Interviews and fieldwork with proprietary trading firms, including high frequency trading firms.

"Another area of concern is that some firms do not have stringent processes for the development, testing, and deployment of code used in their trading algorithms. For example, a few trading firms interviewed said they deploy new trading strategies quickly by tweaking old code and placing it into production in a matter of minutes. In fact, one firm interviewed had two incidents of out-of-control algorithms. To address the first occurrence, the firm added additional pre-trade risk checks. The second out-of-control algorithm was caused by a software bug that was introduced as a result of someone fixing the error code that caused the first situation."

<p>United States Federal Reserve Bank of New York, Treasury Market Practices Group, "Automated Trading in Treasury Markets" (2015)</p>	<p>U.S. Treasuries, 2014, and participant interviews</p>	<p>"Electronic trading in the Treasury markets has arguably improved overall liquidity through enhanced order flow and competition, thus reducing trading costs and allowing market participants to more effectively manage risk. Some have also reasoned that automated trading has improved market efficiency by reducing valuation discrepancies across related markets. However, the increased adoption of automated trading has also led market participants and regulators to articulate concerns about the potential for greater operational risk, disruptive market practices and trading strategies, and the risk of sharp, short-term disruptions to the Treasury securities market of the kind experienced in the equities and futures markets, which have a significant automated trading presence."</p>
<p>United States Federal Trade Commission, "Report of the Federal Trade Commission on the Grain Trade," Volume 7 (1926)</p>	<p>U.S. futures, 1915-1922</p>	<p>Unregulated or poorly regulated market makers both cause and exacerbate price volatility; "The scalpers who operate with reference to fractional changes within the day may have a stabilizing effect on prices so far as such changes with the day are concerned, but when the market turns they run with it, and they may accentuate an upward or downward movement that is already considerable."</p>
<p>United States Securities and Exchange Commission, "Barclays, Credit Suisse Charged with Dark Pool Violations: Firms Collectively Paying More Than \$150 Million to Settle Cases" (2016)</p>	<p>Trading firm U.S. equities data and trading firm procedures and customer materials, 2008-2014</p>	<p>"The Securities and Exchange Commission today announced that Barclays Capital Inc. and Credit Suisse Securities (USA) LLC have agreed to settle separate cases finding that they violated federal securities laws while operating alternative trading systems known as dark pools and Credit Suisse's Light Pool."</p> <p>See also "A.G. Schneiderman Announces Landmark Resolutions With Barclays And Credit Suisse For Fraudulent Operation Of Dark Pools".</p>
<p>United States Securities and Exchange Commission, "SEC Charges Knight Capital With Violations of Market Access Rule" (2013)</p>	<p>Trading firm U.S. equities data and trading firm procedures, 2012.</p>	<p>"An SEC investigation found that Knight Capital did not have adequate safeguards in place to limit the risks posed by its access to the markets, and failed as a result to prevent the entry of millions of erroneous orders."</p>
<p>United States Securities and Exchange Commission, "SEC Charges New York-Based High Frequency Trading Firm With Fraudulent Trading to Manipulate Closing Prices" (2014)</p>	<p>U.S. equities, 2009</p>	<p>"The Securities and Exchange Commission today sanctioned a New York City-based high frequency trading firm for placing a large number of aggressive, rapid-fire trades in the final two seconds of almost every trading day during a six-month period to manipulate the closing prices of thousands of NASDAQ-listed stocks."</p>

<p>United States Securities and Exchange Commission, "SEC Charges Direct Edge Exchanges With Failing to Properly Describe Order Types" (2015)</p>	<p>U.S. exchange rule filings, exchange communications</p>	<p>"These exchanges did not properly describe in their rules how their order types were functioning," said Andrew J. Ceresney, Director of the SEC's Division of Enforcement. "They also gave information about order types only to some members, including certain high-frequency trading firms that provided input about how the orders would operate."</p>
<p>See also "For Superfast Stock Traders, A Way to Jump Ahead in Line."</p>		
<p>United States Securities and Exchange Commission, "Latour Trading Charged with Market Structure Rule Violations" (2015)</p>	<p>U.S. equities, 2010-2014</p>	<p>"The Securities and Exchange Commission today charged Latour Trading LLC with violating SEC rules designed to ensure safe and efficient markets. Latour, a high-frequency proprietary trading firm, agreed to a settlement in which it will pay a \$5 million civil penalty and more than \$3 million of disgorgement of gross trading profits, rebates paid to it by exchanges, and prejudgment interest."</p>
<p>Van der Wel, Menkveld, Sarkar, "Are Market Makers Uninformed and Passive? Signing Trades in the Absence of Quotes" (2009)</p>	<p>U.S. futures, 1994-1997</p>	<p>Unregulated or poorly regulated market makers demand liquidity for a substantial part of the day and are active and informed speculators.</p>
<p>Federal Reserve Bank of New York</p>		
<p>Van Kervel, "Market Fragmentation and Smart Order Routing Technology" (2014)</p>	<p>U.K. equities, 2009</p>	<p>"However, after a trade on one venue, [HFT market makers] will quickly withdraw the additional liquidity on the other. The empirical analysis confirms that trades are followed by excessive cancellations of limit orders, and the magnitude depends on the fraction of traders who can access several venues simultaneously."</p>
<p>VU University Amsterdam</p>		
<p>See also Nasdaq, "Self-Regulatory Organizations: The NASDAQ Stock Market LLC; Notice of Filing of Proposed Rules Change to Amend Rule 4758(a)(1)(A) to Reflect a Change in Nasdaq's Routing Functionality"</p>		
<p>Van Kervel, Menkveld, "High-Frequency Trading around Large Institutional Orders" (2016)</p>	<p>Swedish equities, 2011-2013</p>	<p>"We find that HFTs initially lean against an order (trade in the direction opposite to it) but, if the order lasts more than a couple of hours, they then turn around and go with the order. HFT gross profit is positive either way. Institutional investors' costs are lower for against-wind HFT net flow but disproportionately larger for with-wind HFT flow. Against-wind trading by HFTs is generally consistent with classic market making. The novel finding of with-wind high-frequency trading largely supports recent theory on intermediaries backrunning on</p>
<p>Pontifical Catholic University of Chile and Tilburg Law and Economics Center</p>		

informed orders (Yang and Zhu, 2015). With–wind trading occurs only after several hours, which could be interpreted as the initial learning period. Further analysis on the cross section of institutional orders reveals that, all else being equal, larger permanent price impacts correlate positively with HFT with–wind activity. HFTs seem to run on the most informed orders. HFT back-running on institutional orders does not necessarily improve market quality. One could argue that prices become more efficient in the short run. HFT trading in the same direction as informed investors makes prices reveal private information more quickly. The worrisome side effect is that, in the long run, prices could become less efficient. Institutional investors could discontinue costly analyst research, since informational rents have to be shared with others in the trading process. Research might no longer be privately profitable. "

Venkataraman, Waisburd, " The Value of the Designated Market Maker " (2006)	French equities, 1995-1998	Designated market makers with affirmative obligations improve market quality, increase market valuation.
Southern Methodist University		
Wah, " How Prevalent and Profitable are Latency Arbitrage Opportunities on U.S. Stock Exchanges? " (2016)	U.S. equities, 2014	"This paper provides evidence that high-frequency traders have numerous opportunities to realize profits from latency arbitrage. These opportunities are significantly more prevalent in larger stocks and on certain exchanges. I estimate that total potential profit from latency arbitrage opportunities in S&P 500 ticker symbols was approximately \$3.03 billion in 2014."
Wang, Chae, " Who Makes Markets? Do Dealers Provide or Take Liquidity? " (2003)	Taiwanese equities, 1997-2002	Absent mandatory obligations, market maker privileges don't induce market makers to provide liquidity; they derive profits from their own informed trades; "While dealers may be meant to perform the socially beneficial function of liquidity provision, the institutional advantages granted to them also give the ability to act as super-efficient proprietary traders if they choose to."
Massachusetts Institute of Technology		
Weild, Kim, Newport " The Trouble with Small Tick Sizes " (2012)	U.S. equities, 1991-2011	"Rather than supporting long-term company growth by bringing research, sales and capital to investors, high-frequency traders seek to make a quick profit by identifying short-term price discrepancies."
Grant Thornton		
Weller, " Liquidity and High Frequency Trading " (2012)	U.S. futures	"[T]he introduction of fast, low-capital intermediaries can render markets less able to bear large liquidity demand shocks. The sudden prevalence of flash crashes—Nanex, a market data feed provider, estimates more than 1,800 miniature flash crashes occurred
University of Chicago		

in 2010 alone—is not surprising when viewed from this perspective."

Note that access to this paper has been restricted. See "[The Influence of the For Profit Exchanges](#)".

<p>Weller, "Efficient Prices at Any Cost: Does Algorithmic Trading Deter Information Acquisition?" (2016)</p>	<p>U.S. equities, 2012-2015</p>	<p>"[A]lgorithmic liquidity consumers may sufficiently erode information rents to deter utilization of costly information sources if they better learn from or anticipate order flow, as in Yang and Zhu (2015) or, more colorfully, in Michael Lewis' <i>Flash Boys</i>....Consistent with order anticipation explanations, I find that algorithmic liquidity takers are associated with significantly reduced information acquisition, whereas AT liquidity providers' effects are ambiguous. Although these market participants and mechanisms have analogues in the human-dominated trading era, technological developments have shifted the balance between liquidity providers and demanders and informed and uninformed market participants."; "Although algorithmic liquidity provision may be associated with increased information acquisition, its effects are swamped by the damage wrought by aggressive algorithmic traders.";</p>
<p>Northwestern University</p>		
<p>Working, "Tests of a Theory Concerning Floor Trading on Commodity Exchanges" (1967)</p>	<p>U.S. futures, 1952</p>	<p>Unregulated or poorly regulated market makers are also trend traders, profiting from the information advantages of privileged access; they can trade aggressively, especially when the market goes against the firm; inventory cycles of "minutes"; trend trading accelerates price changes (but the author believes may moderate extremes).</p>
<p>Stanford University</p>		
<p>Yadav, "The Failure of Liability in Modern Markets" (2015)</p>	<p>Literature review</p>	<p>"With error inextricably a part of predictive, pre-set algorithms, liability can arise too frequently to function as an informative signal of bad behavior. Further, small errors can create large-scale losses that may be too high for any single firm to pay. Finally, punishing only intentional bad actors leaves a swath of the market unsanctioned for careless behavior. With each standard falling short, the current design of the liability framework can leave markets facing pervasive costs of mistake, manipulation and disruption. In concluding, this weakening of laws points to a need for structural solutions in automated markets. This Article explores avenues for reform to institutionalize better behavior and fill the gaps left by the law."</p>
<p>Vanderbilt University Law School</p>		
<p>Yadav, "How Algorithmic Trading Undermines Efficiency in Capital Markets" (2015)</p>	<p>Literature review</p>	<p>"Algorithmic trading weakens the ability of prices to function as a window into allocative efficiency....Competing with high-speed, algorithmic counterparts, informed traders</p>

can see lower returns from their engagement. When informed traders lose interest in bringing insights to securities trading, prices are less rich as a result."

<p>Ye, Yao, Gai, "The Externality of High Frequency Trading" (2013) University of Illinois</p>	<p>U.S. equities, 2010</p>	<p>"We find that stocks randomly grouped into the same channel have an abnormal correlation in message flow, which is consistent with the quote stuffing hypothesis."; "We find that exogenous technology improvements improving speed at a one millisecond, microsecond or nanosecond level do not lead to improvements on quoted spread, effective spread, trading volume or variance ratio. However, the cancellation/execution ratio increases, short term volatility increases and market depth decreases."</p>
<p>Yildiz, Van Ness, Van Ness, "The Role of HFT's in Order Flow Toxicity and Stock Price Variance" (2014) University of Mississippi</p>	<p>U.S. equities, 2008-2009</p>	<p>"The toxicity of pure HFT trades (HH) is nearly 40% higher than pure non-HFT trades (NN). The toxicity problem is more severe in low volume stocks than high volume and medium volume stocks. We provide empirical evidence to support the theoretical predictions...that HFTs may play a dysfunctional role in financial markets."</p>
<p>Zhang, "High-Frequency Trading, Stock Volatility, and Price Discovery" (2010) Yale University</p>	<p>U.S. equities, 1985-2009</p>	<p>"[H]igh-frequency trading may potentially have some harmful effects" because "high-frequency trading is positively correlated with stock price volatility."</p>
<p>Zigrand, Cliff, Hendershott, "Financial stability and computer based trading" (2011) London School of Economics</p>	<p>Literature review</p>	<p>Self-reinforcing feedback loops in computer-based trading can lead to significant instability in financial markets; market participants become inured to excessive volatility in a cultural "normalization of deviance" until a large-scale failure occurs; research to date has not shown a persistent increase in market volatility, but HFT research is nascent.</p>

The Wall Street Journal's "Dark Market" Series (selected articles)

["Deutsche Börse's News Service for Traders Draws Scrutiny of Investigators"](#)

Brody Mullins and Scott Patterson, August 12, 2013

"[N]ow owned by the Deutsche Börse stock exchange, Need To Know News has operated with an overriding mission: sending data directly from the government through high-speed lines to financial firms that are able to trade on it instantly. Some have paid \$375,000 a year for the service."

["High-Frequency Traders' Safeguards Come Under Scrutiny"](#)

Scott Patterson, July 18, 2013

"The widening look at high-speed algorithms was sparked by Finra's recent investigations into high-speed-trading mishaps, Mr. Gira said. Last week, Finra and several stock-exchange regulators fined Newedge USA LLC, which is jointly owned by French banks Société Générale and Crédit Agricole CIB, \$9.5 million for lax oversight of computer-driven trading firms."

["High Speed Traders Exploit Loophole"](#)

Scott Patterson, May 1, 2013

"Fast-moving traders can get a head start in looking at key information because they connect directly to the exchange's computers, giving them the data just before it reaches the so-called public tape accessible to everyone else."

["High-Speed Traders Race to Fend Off Regulators"](#)

Jenny Strasburg and Scott Patterson, December 28, 2012

"High-frequency trading firms are fighting to fend off regulation as scrutiny of their practice of unleashing blizzards of orders coincides with repeated technical glitches in the markets. As the firms work to convince policy makers their practices are benign or even beneficial, one of their primary tools has been research seeded by the industry itself, promoted by lobbying that has increased in recent years."

["Probe Sparks Split on Trades"](#)

Scott Patterson, December 18, 2012

"A regulatory investigation into whether stock exchanges have given unfair advantages to high-speed traders has sparked complaints against the exchanges, fueling a broader debate about how the market operates and is regulated."

["BATS Forced to Correct Statements by President O'Brien on How Its Exchanges Work"](#)

Scott Patterson, April 3, 2014

"BATS Global Markets Inc., under pressure from the New York Attorney General's office, corrected statements made by a senior executive during a televised interview this week about how its exchanges work."

See also ["The 'Flash Boys' fight that stopped NYSE trading."](#)

["How One Whistleblower Turned the Tables on High-Frequency Traders"](#)

Scott Patterson, August 4, 2014

"A once esoteric corner of the stock market — "order types" — has taken center stage the past few years in the debate about the health of the market, the role of high-speed traders in it and how stock exchanges interact with clients."

["Dark Pool' Settlements Bring Tangled Relationships to Light"](#)

Scott Patterson, February 1, 2016

"The latest round of penalties over "dark pools" highlights how reliant banks and exchange operators have become on business from high-frequency traders—even on platforms that promised to blunt their advantage."

["Exchanges Get Closer Inspection"](#)

Scott Patterson and Jean Eaglesham, November 20, 2012

"[R]egulators are stepping up oversight of stock exchanges as they scramble to catch up to trading advantages that some say have developed for sophisticated clients at the expense of ordinary investors."

["For Superfast Stock Traders, A Way to Jump Ahead in Line"](#)

Scott Patterson and Jenny Strasburg, September 19, 2012

"At issue is whether exchanges sometimes allow high-speed trading firms to trade ahead of less-sophisticated investors, potentially disadvantaging them and violating regulatory rules."

See also ["SEC Charges Direct Edge Exchanges With Failing to Properly Describe Order Types"](#).

For an index of the Wall Street Journal's "Dark Markets" series, see <http://topics.wsj.com/subject/D/dark-markets/6986>.

High Frequency Trading and "Insider Trading 2.0"

In 2013, Nanex, LLC, a market data and market research firm, [documented several instances](#) where markets reacted violently to news reports and press releases *before* they were generally available to the public. As a result of Nanex's research and other investigative reporting, news and other information services were called to account for selling early access to high speed trading firms. Christening these practices "Insider Trading 2.0," the New York Attorney General launched an [investigation](#), the U.S. Federal Reserve [changed its procedures](#), and even Warren Buffett [stepped in](#).

Researchers also found that the Securities and Exchange Commission inadvertently gave [high-speed traders advance looks at corporate filings](#).

["Thomson Reuters Gives Elite Traders Early Advantage"](#)

Eamon Javers, CNBC, June 12, 2013

"A closely watched consumer confidence number that routinely moves markets upon release is accessed by an elite group of traders, for a fee, a full two seconds before its official release, according to a document obtained by CNBC."

["Traders Pay for an Early Peek at Key Data"](#)

Brody Mullins, Michael Rothfeld, Tom McGinty and Jenny Strasburg, Wall Street Journal, June 12, 2013

"On the morning of March 15, stocks stumbled on news that a key reading of consumer confidence was unexpectedly low. One group of investors already knew that. They got the University of Michigan's consumer report two seconds before everyone else....In a single second, according to a Wall Street Journal analysis, traders from various firms bet nearly seven million shares that equity markets would decline - which was exactly what happened when news of the survey became widely known."

["A.G. Schneiderman Applauds Decision By Business Wire To Prohibit High-Frequency Traders From Purchasing Direct News Feed"](#)

New York Attorney General Press Office, February 20, 2014

"High-frequency traders who drain the value out of market-moving information in the milliseconds before it becomes available to other investors erode confidence in our markets and skim from the rest of the investing public, which hurts the entire market."

["Fast Traders Are Getting Data From SEC Seconds Early"](#)

Ryan Tracy and Scott Patterson, Wall Street Journal, October 29, 2014

"Hedge funds and other rapid-fire investors can get access to market-moving documents ahead of other users of the Securities and Exchange Commission's system for distributing company filings, giving them a potential edge on the rest of the market."

Press Editorials

["Stopping the Stock Market Arms Race"](#)

Bloomberg, June 16, 2014

"When large investors such as mutual funds try to trade at quoted prices, the shares disappear from their screens. High-speed traders place and cancel millions of orders a day to sniff out demand. When they detect interest in a stock, they jump ahead and buy the shares on all the markets, then sell them to fund managers at a slightly higher price." See also these Bloomberg editorials: ["Wall Street Trades at Speed of Light Need Traffic Cops: View"](#) (January 3, 2012), ["Knight Blowup Shows How High-Speed Traders Outrace Rules"](#) (August 7, 2012), ["U.S. Leads in High-Frequency Trading, Trails in Rules"](#) (October 2, 2012), ["High-Frequency Trading Prospers at Expense of Everyone"](#) (December 26, 2012)

["Wait a second: The latest cock-up on Wall Street shows that more safeguards are needed"](#)

Economist, August 11, 2012

"This newspaper seldom finds itself on the side of restraining either technology or markets. But in this case there is a doubt whether the returns justify the risk. Society needs a stockmarket to allocate capital efficiently, rewarding the best companies with higher share prices. But high-frequency traders are not making decisions based on a company's future prospects; they are seeking to profit from tiny changes in price. They might as well be trading baseball cards. The liquidity benefits of such trading are all very well, but that liquidity can evaporate at times of stress. And although high-frequency trading may make markets less volatile in normal times, it may add to the turbulence at the worst possible moment."

["Dredging Wall Street's dark pools"](#)

Financial Times, June 26, 2014

"[T]echnological innovation has outpaced market supervision to the detriment of investors. The US authorities are finally waking up to the problem. Mr Schneiderman has opened an inquiry into whether US stock exchanges and other trading platforms have given high-speed traders an undue advantage. The SEC wants to force more disclosure on dark pools...These are welcome initiatives. Equity markets are not the playground of traders but places where retail investors deploy their savings. As regulators catch up with reality, they must make sure that markets serve non-professional users that access them." See also these Financial Times editorials: ["Taming Trading"](#) (August 23, 2010), ["Calmer markets"](#) (October 4, 2010), ["Asia takes on algos"](#) (August 14, 2012), and ["Expelling gremlins from the exchange"](#) (August 23, 2013).

["Volatile markets: twitchy about Twitter"](#)

The Guardian, April 26, 2013

"Using algorithms, dealing-room computers conduct hundreds of thousands of automatic trades within seconds. These can sometimes steady or smooth markets, as when algorithms correct an error made by a fat-fingered human. But other times they can make things worse, by exacerbating a dramatic move in asset prices."

["When Speed Kills"](#)

The Japan Times, August 14, 2012

"Market officials and regulators are increasingly skeptical of the notion that faster is by definition better."

["Trading in the Dark"](#)

The New York Times, April 7, 2013

"Potential interactions between the off-exchange venues and the high-speed, computer-driven trading

that now dominates the stock market are also cause for worry, because increasingly complex systems can malfunction in unexpected and catastrophic ways." See also ["The Dark Pool Iceberg"](#) (June 28, 2014).

["SEC right to look hard at 'dark pools'"](#)

Newsday, June 10, 2014

"In the past week, Securities and Exchange Commission Chairwoman Mary Jo White has started to make some meaningful moves to help. She proposed a broad set of new rules to strengthen oversight, improve disclosure and limit the risk of market meltdowns. Chief among them is improving oversight of high-speed traders who use computers to take lightning-fast advantage of tiny opportunities in the market. These traders are not required to register with the SEC or the Financial Industry Regulatory Authority, a private company that acts as a self-regulating organization for the markets. It was high-speed trading that caused the Dow Jones industrial average to drop 700 points in minutes in 2010."

["Flash crash' arrest sets off alarms: Our view"](#)

USA Today, April 22, 2015

"[E]xchanges are not in the business of underpinning capitalism; they are in the business of boosting trading profits. They care less about money managers entrusted with trillions of people's hard-earned dollars than they do about traders who will buy and sell a stock thousands of times in a split second. These ['Flash Boys'](#) account for the bulk of trades, and the bulk of fees paid to exchanges....Too many people are making too many trades — legal or otherwise — that have nothing to do with fundamentals and that leave the rest of us vulnerable." See also these USA Today editorials: ["High-frequency trading corrupts markets: Our view"](#) (April 1, 2014), ["Flash-crash analysis leaves investors reason to worry"](#) (October 7, 2010), ["Time to put the brakes on high-frequency stock trades"](#) (May 18, 2010), ["High-frequency trading insanity"](#) (September 26, 2012).

["The Dark of Knight"](#)

Wall Street Journal, August 2, 2012

"From the 2010 'flash crash' to trading snafus at Facebook's initial public offering in May, the basic plumbing of the equity markets has never seemed so troubled."

["Is high-frequency stock trading stepping over a legal line?"](#)

Washington Post, April 10, 2014

"Clearly, a new generation of high-frequency traders has figured out how to arbitrage - or exploit - a time advantage, measured in fractions of a second....We can't slow down technology, but we should insist on rules to keep markets free, open and fair."

Op-Eds and Commentary

["Themis Trading Opening Statement from CFTC TAC Panel on High Frequency Trading"](#)

Sal Arnuk and Joseph Saluzzi, Themis Trading, June 4, 2014

"The best solutions to complexity are usually simple ones. We have three that we believe can change equity markets for the better."

See also the [Themis Trading Blog](#), where Sal Arnuk and Joe Saluzzi write some of the most thoughtful commentary on the markets anywhere.

["What Really Happened in the US Government Bond Market on the Morning of October 15th?"](#)

Sal Arnuk and Joseph Saluzzi, Themis Trading, October 21, 2014

"[S]omething is wrong when the safest bonds in the world experience such a rapid price move in such a short time period. Unfortunately, we say to our bond market friends, welcome to our world!"

["Stock-Order Rebates Should Be Stopped, Arnuk Says"](#)

Sal Arnuk and Joseph Saluzzi interviewed by Erik Schatzker and Stephanie Ruhle

Bloomberg, September 20, 2012

"What we've done is we've taken two deep liquidity pools and taken their worst feature - the worst feature - amplified it a billion times, mechanized it, and now that is our modern market structure."

["Serving All, Not Just the Elite Few"](#)

Sal Arnuk and Joseph Saluzzi, New York Times Room for Debate, August 6, 2012

"Trading today is mostly computerized scalping done under a sanitized name – 'market making.'"

["Trying to Force the S.E.C.'s Hand on High-Speed Trading"](#)

Robert P. Bartlett III and Justin McCrary, New York Times, December 28, 2015

"A recurring theme in the IEX application is that the quiet revolt by investors outlined in 'Flash Boys' has now become a full-fledged movement for a referendum on our speed-based market structure."

["Too Fast to Fail: Is High-Speed Trading the Next Wall Street Disaster?"](#)

Nick Baumann, Mother Jones, January/February, 2013

"The chief executives of publicly traded companies—who are hired and fired based on stock prices—increasingly worry that their shares could be sent into a free fall by an algorithmic feeding frenzy. The current markets have created a 'somewhat disjointed world between what a company does and what its stock does,' the CEO of one billion-dollar, NYSE-traded company told *Mother Jones*."

See also ["Yet More Evidence That High-Frequency Trading is Bad for Us"](#) (December 4, 2012).

["HFT leads small issuers to exit public listings"](#)

David Beatty, Financial Post, September 4, 2014

"Since the onset of high frequency trading and the erosion of true market makers, liquidity in public companies has been concentrating in an ever smaller group of large-cap stocks. As a consequence of increasing costs, caused by HFT-driven market dynamics, dealers have been downsizing their sales support and research capability for small and mid-sized corporations."

["Cash Cow - High-Frequency Trading"](#)

Samantha Bee, The Daily Show, September 30, 2009

"We've all heard that the way to make money in the stock market is to invest in a company you believe in

and hold on to that stock. Well, there's a name on Wall Street for people who do that: *Suckers!*"

["Introduction to HFT Scalping Strategies"](#)

Haim Bodek and Mark Shaw, Decimus Capital Markets, LLC / Haim Bodek Consulting, November 2012
"HFT scalping's impact on the equity markets include high frequency price fluctuations, high order cancellation rates and liquidity gaps."

["MoneyBeat: Memory of 'Flash Crash' Weighs on Markets and Regulators"](#)

E. S. Browning, Wall Street Journal, May 4, 2015

"Nearly five years after the "flash crash" rocked financial markets, people who have studied it warn that some form of repeat event can't be ruled out."

["HFT isn't the problem - insider trading is"](#)

Mercer Bullard, University of Mississippi Law School, April 4, 2014

"In a market dominated by electronic trading, investors are having their pockets picked—and individual investors and mutual fund shareholders are among the likely victims."

["Not so fast: The risks posed by high-frequency trading"](#)

Buttonwood, Economist, August 6, 2011

"The problem may be that, unlike marketmakers, HFT investors have no obligation to trade in difficult conditions." See also Buttonwood's notebook, ["HFT: the backlash continues"](#) (May 7, 2014).

["Rise of the Machines"](#)

Citizens for Responsibility and Ethics in Washington, May 13, 2013

"CREW studied the lobbying and campaign contribution records of 48 companies known for high frequency trading. Their campaign contributions soared by a staggering 673 percent between the 2008 and 2012 cycles, and their lobbying spending jumped 93 percent."; "HFTs have aggressively commissioned research and circulated it on Capitol Hill to buttress arguments against regulation."

["SEC must put a stop to casino markets"](#)

Leon Cooperman, Sal Arnuk and Joseph Saluzzi, Financial Times, September 24, 2012

"Clearly, the SEC's market structure experiment has failed. Unless something changes, confidence-shaking events will only increase in frequency."

["High Frequency Trading Reform: The Short Term and the Longer Term"](#)

John C. Coffee, Columbia Law School, July 21, 2014

"[H]igh frequency traders will argue that, if they could not purchase their current trading advantages, they would be less willing to intervene aggressively in equity markets to narrow the spreads. The cost of reform thus might be wider spreads. This is not false, but the advantages of their aggressive intervention may be exaggerated. The social benefits from high frequency trading are uncertain and possibly illusory."

["The Responsible Way to Rein in Super-Fast Trading"](#)

Gary Cohn, Wall Street Journal, March 20, 2014

"In the past year alone, multiple technology failures have occurred in the equities markets, with a severe impact on the markets' ability to operate. Even though industry groups have met after the market disruptions to discuss responses, there has not been enough progress. Execution venues are decentralized and unable to agree on common rules. While an industry-based solution is preferable, some issues cannot be addressed by market forces alone and require a regulatory response."

["Measures needed to curb advantage of High Frequency Trading"](#)

Richard Curran, Irish Independent, February 27, 2014

"But when it comes to the utilisation of multi-million dollar software, located next to the exchange server, combined with the purchase of early information that is potentially market moving, somebody has to cry halt."

["Defining high-frequency trading's US level of evil"](#)

John Dizard, Financial Times, June 20, 2014

"On Wall Street, people's sentiments about high-frequency equities trading is largely determined by whether they believe there is plenty of liquidity to go around, or not. (In Europe, there is agreement across the political spectrum that HFT is inherently evil.)"

["The Day The Market Almost Died \(Courtesy Of High Frequency Trading\)"](#)

Tyler Durden, ZeroHedge, May 6, 2010

"What happened today was no fat finger, it was no panic selling by one major account: it was simply the impact of everyone in the HFT community going from port to starboard on the boat, at precisely the same time."

See also http://www.zerohedge.com/taxonomy_vtn/term/140 and http://www.zerohedge.com/taxonomy_vtn/term/12411

["Regulator puts a spotlight on high-frequency trading "](#)

Boyd Erman, The Globe and Mail, June 18, 2012

"From retail investors commenting on The Globe and Mail's website to Tony Fell, who once ran the country's biggest brokerage, the message is the same: The markets are seen as a casino where high-frequency traders are winning too often for it all to be just chance."

["A new type of market crash proliferates"](#)

The Economist, August 31, 2013

"Even before the glitches, the SEC was taking increased interest in potential trading problems and how they might be disclosed. In March it published a proposal known as Regulation SCI (systems compliance and integrity). Exchanges and banks are resisting one of its requirements, which is to report blackouts even if they do not lead to anything as severe as trading halts. America's regulators are often accused of being heavy-handed. But forcing more transparency on the black boxes that have replaced screaming humans on Wall Street must be a good thing."

["High Frequency Trading HFT panel \(Finance Watch Conference\)"](#)

Finance Watch (2012)

"Significant concerns have been raised about the quality of liquidity provided, as well as the risks posed in terms of stability and integrity for our financial markets by these types of trading."

See also www.finance-watch.org.

["Dark times for opaque trading platforms"](#)

Jeremy Grant, Financial Times, June 26, 2014

"It has been an open secret in the industry that some bank dark pools have admitted certain kinds of HFT players, in spite of their blandishments to the contrary."

["High-frequency trading and the \\$440m mistake"](#)

August 10, 2012

Tim Harford, BBC Radio 4

"Humans still watch the systems, but the computers move far too quickly for us to react to everything they do - and at Knight Capital, the computer glitch meant the company was making trades it didn't intend to make. That's how to lose almost half a billion dollars in a little over half an hour."

["Toward A U.S. Equity Market Structure That Serves All Investors"](#)

Micah Hauptman, Consumer Federation of America (2014)

"While competition and technology have brought great progress to our equity markets, the pendulum has swung too far. Excessive competition has resulted in a market that is unnecessarily complex, fragmented, lacking basic transparency mechanisms, and ridden with conflicts of interest; and, the technological arms race has led to trading activities that disadvantage long-term investors, expose the financial system to excessive risks, and shake investor confidence."

["High frequency trading needs severe regulation"](#)

Anthony Hilton, London Evening Standard, October 23, 2012

"HFT is now so dominant it overwhelms everyone so there is no countervailing force to the direction taken by the computers."

["Risiken des Hochfrequenzhandels: Das systemische Risiko der Dummheit"](#) ("Risks of High Frequency Trading: The Systemic Risk of Stupidity")

Yvonne Hofstetter, Frankfurter Allgemeine, October 15, 2013

"Ultra-fast trading algorithms are a systemic risk to our economy - all the more so when no one seems to be able to control their behavior." ([Google Translate](#))

["Traders may have gotten last week's Fed news 7 milliseconds early"](#)

Neil Irwin, The Washington Post Wonkblog, September 24, 2013

"It is the reality of how much trading activity, particularly of the ultra-high-frequency variety is really a dead weight loss for society."

["The high-tech arms race that's causing stock market 'tsunamis'"](#)

Neil Johnson, CNN, August 13, 2014

"My fellow researchers and I recently uncovered glimpses of what is already going wrong in the form of escalating patterns of 'sub-second tsunamis.' These tsunamis are huge spikes and dips in the price of an individual stock. Although the Flash Crash was fast, lasting only a few minutes, these sub-second tsunamis are over in the blink of an eye -- and there are thousands of them. A 10% daily change in a major stock would guarantee breaking news coverage, but these tsunamis typically send the price plummeting to almost zero. However they go unnoticed since the price quickly recovers as other algorithms jump in for the kill."

["Closer Look: No Rewind Button for Everbright Securities"](#)

Fan Junli, Caixin Online, August 19, 2013

"The Everbright incident has raised alarms on the limits of risk control and supervision capacity in HFT, which refers to rapid securities trading that relies on technological tools and computer algorithms."

["Shining some light into the monied world's 'dark pools'"](#)

Ted Kaufman, Delaware Online, February 16, 2015

"High Frequency Trading (HFT) now accounts for over fifty percent of all trading volume in the United States. It began to grow rapidly when SEC rules were changed to allow the movement of stock trading away from a few exchanges. Much of that trading is now done in "dark pools," so named because they aren't required to have the transparency of the traditional exchanges. That means no one, including the

SEC, knows what is going on as High Frequency traders use super-fast computer algorithms to find and exploit price variations that may come and go in nanoseconds."

["Preventing the Next Flash Crash"](#)

Edward [Ted] E. Kaufman Jr and Carl M. Levin, New York Times, May 5, 2011

"America's capital markets, once the envy of the world, have been transformed in the name of competition that was said to benefit investors. Instead, this has produced an almost lawless high-speed maze where prices can spiral out of control, spooking average investors and start-up entrepreneurs alike."

["A Dark Magic: The rise of the robot traders"](#)

Laurence Knight, BBC News, July 8, 2013

"But, what made things far worse was a 'hot potato' effect: amid the confusion, one by one the robot traders tried to cut and run, and the stock exchange's computers got swamped."

["Testimony on 'Computerized Trading: What Should the Rules of the Road Be?'"](#)

David Lauer testimony before the U.S. Senate Committee on Banking, Housing, and Urban Affairs Subcommittee on Securities, Insurance and Investment, September 20, 2012

"US equity markets are in dire straits. We are truly in a crisis."

["Public Comment on Consultation Report"](#)

R. T. Leuchtkafer, August 12, 2011

"A basic function of any market is to produce a quote. Today's HFT quotes are toxic, a hoax on equities markets."

See also ["No more 'hot potatoes' please"](#) (October 5, 2010) and ["File No. 07-02-10"](#) (April 16, 2010).

["Why Couldn't Wall Street Weather a Storm?"](#)

Arthur Levitt, Wall Street Journal, November 7, 2012

"And thanks to software errors in high-speed trading firms and 'fat finger' errors by human traders, it's becoming clearer that many major market participants simply have not properly tested their existing trading systems or prevented fraud and error from creeping into their trading books."

["High-frequency trading - split seconds"](#)

Lex, Financial Times, September 26, 2012

"Constraining the relentless advance of technology is rarely easy. But that is no excuse for not trying when its potential effects may be damaging."

["A Speed Limit for the Stock Market"](#)

Roger Lowenstein, New York Times, October 1, 2012

"The 'liquidity' H.F.T. provides is long past the point of being helpful."

["One Way to Unrig Stock Trading"](#)

Jonathan Macey and David Swensen, New York Times, December 24, 2015

"High-frequency traders pay to locate their computer servers inside of exchanges' order execution centers, where they get early access to trade information that they use to jump in front of — front run — other clients. These co-located computers detect orders to buy and sell on one exchange and then rapidly send cancellations and orders to other venues where their servers are also co-located. Does this sound like a fair system?"

["Be Grateful for Drizzle"](#)

Donald MacKenzie, London Review of Books, September 11, 2014

"In a New York coffeehouse, a former high-frequency trader told me matter of factly that one of his colleagues had once made the simplest of slip-ups in a program: what mathematicians call a 'sign error', interchanging a plus and a minus. When the program started to run it behaved rather like the Knight program, building bigger and bigger trading positions, in this case at an exponential rate: doubling them, then redoubling them, and so on. 'It took him 52 seconds to realise what was happening, something was terribly wrong, and he pressed the red button,' stopping the program. 'By then we had lost \$3 million.' The trader's manager calculated 'that in another twenty seconds at the rate of the geometric progression,' the trading firm would have been bankrupt, 'and in another fifty or so seconds, our clearing broker' – a major Wall Street investment bank – 'would have been bankrupt, because of course if we're bankrupt our clearing broker is responsible for our debts ... it wouldn't have been too many seconds after that the whole market would have gone.'"

["Markets: In search of a fast buck"](#)

Arash Massoudi and Michael Mackenzie, Financial Times, February 20, 2013

"The potential benefits to investors seem clear: trading will become cheaper and more transparent...But the potential downsides are markets plagued by computer errors and outages. Most worrying of all: the risk of a global flash crash across major markets linked by the speed traders."

["High Frequency Trading: Wall Street's Doomsday Machine?"](#)

Christopher Matthews, Time Magazine, August 8, 2012

"[H]igh-speed trading systems may also pose risks to the stability of the overall financial system."

["High Frequency Trading - Maybe This Time"](#)

Jim McCaughan, CEO, Principal Global Investors, April 7, 2014

"Technology and the proliferation of trading venues have moved faster than regulation, creating structural issues in markets that need to be addressed. To be clear, neither technology nor the increased number and variety of exchanges is the true issue. In fact, the efficiency of computerized trading and greater choice in trading venues are, on balance, very good things – having improved the process of price discovery and reduced transaction costs for investors. The issue with certain HFT firms is that they take advantage of speed and preferential access to exchanges to engage in predatory trading practices. The New York Attorney General refers appropriately to the situation as 'insider trading 2.0.'"

["Recommendations for Equitable Allocation of Trades in High Frequency Trading Environments"](#)

John McPartland, Federal Reserve Bank of Chicago (2013)

"This paper (1) acknowledges and summarizes much of the relevant published research (2) discusses some of the HFT strategies that likely run counter to good public policy and (3) makes six recommendations that, if implemented, would not preclude any current HFT strategies, but would likely restore some competitive advantage to market participants that would be willing to expose their resting orders to market risk for more than fleeting milliseconds."

["Why High-Frequency Trading Doesn't Compute"](#)

Jim McTague, Barrons, August 11, 2012

"Markets have been jarred by four major computer mishaps this year, including the recent one at Knight Capital. It's time to rein in the Street's speed demons: trading bots."

["If HFT is here to stay it needs regulating"](#)

Paul Murphy, Financial Times, February 23, 2014

"[I]f HFT is here to stay, the broader investor community needs assuring that it is robustly and expertly regulated – and unfortunately there is not a lot of evidence that this is the case."

"The Rise of the HFT Machines"

Nanex, LLC

"The following animated GIF chronicles the rise of the HFT Algo Machines from January 2007 through January 2012."

See also <http://www.nanex.net/FlashCrash/OngoingResearch.html>

"Dennis Kelleher on PBS Discussing High Frequency Trading"

National Business Report interviews Dennis Kelleher, September 20, 2012

"There's been shockingly little done regarding our capital markets since the flash crash."

See also www.bettermarkets.com.

"Cuban, Cooperman: Curb High-Frequency Trading"

Bruno J. Navarro, CNBC, October 2, 2012

(Includes CNBC interviews of Mark Cuban and Leon Cooperman)

"There is no value to HFT, period. End of story."

"Frankenstein Takes Over the Market"

Joe Nocera, New York Times, August 4, 2012

"This week, yet another Wall Street firm most people have never heard of, relying on a computerized trading program that they can't possibly understand, shook investors' faith in the market."

"Role of Exchanges in Well-Functioning Markets"

Norges Bank Investment Management, August 6, 2015

"We view the current latency race as ultimately a dead-end. Modern markets required the speed-up that computer technology and automation provided to exchanges, since it enabled increased competition and lower trade execution costs. However, we are now reaching a point where further latency reduction is both extremely costly and potentially counter-productive."

"Strong and Fast Markets, but No Time to Think"

Floyd Norris, New York Times, August 3, 2012

"The same computerization and increased competition that provided the benefits also weeded out people who had the obligation to step up in times of stress, and virtually eliminated the ability of people and institutions to slow or halt markets when something goes badly wrong."

See also "Sacrificing Sense for Speed in Markets" (April 10, 2014).

"Could high-frequency trading cause another flash crash?"

Proinsias O'Mahony, Irish Times, June 2, 2015

"In fact, it appears HFT can lead to more volatility because markets are increasingly responding to the price changes triggered by computer algorithms rather than to new fundamental information."

"Can High-Frequency Trading Drive the Stock Market Off a Cliff?"

Wei Pan, Alex Sandy Pentland, Ren Cheng and Lisa Emsbo-Mattingly

MIT Sloan Management Review, June 18, 2013

"[H]igh-frequency trades influenced the market price, which then affected the next trades of the high-frequency trading firms. As a result, many of these high-frequency trading firms started to sell together, in

synchrony, which added up to billions of dollars worth of sell trades per second. This was an event of enormous magnitude, even for the U.S. equity market. The synchronized selling caused prices to collapse."

["A Dark Magic"](#)

Robert Peston, BBC Radio 4, July 7, 2013

"And what may disturb you is that it's like a terminator movie with competing algorithms clashing with each other and on occasion causing market meltdowns."

["Trading algorithmique: mobilisation contre la 'menace' des ordinateurs boursiers"](#) ("Algorithmic Trading: mobilization against the 'threat' of trading computers")

Edouard Pflimlin, Le Monde, May 20, 2013

"The battle against the excesses of algo-trading only start." ([Google Translate](#))

["How high-frequency traders chisel genuine investors"](#)

Pierpont, Australian Financial Review, July 4, 2014

"One of the most important roles of any stock exchange is to raise capital for companies. HFTs make big money for themselves but never contribute a cent to capital raisings."

["Long-term investors would benefit from Tobin tax"](#)

John Plender, Financial Times, September 28, 2011

"It is a paradoxical result of increased competition from off-exchange trading platforms and from regulatory developments such as Europe's Markets In Financial Instruments Directive that long-term investors are being disadvantaged. A financial transactions tax might help redress the balance."

["Macchine superveloci contro esseri umani: Ecco a voi il mercato iniquo e asimmetrico"](#) [Superfast machines against humans: Here's the unfair and unbalanced market]

Federico Rampini, la Repubblica, April 20, 2012

"La vittima inconsapevole dell'alta frequenza, infatti, siamo tutti noi: ovvero i risparmiatori che affidano in gestione i propri soldi a banche, fondi comuni, assicurazioni, le cui strategie d'investimento vengono travolta dai predatori dell'Hft." ["The unwitting victim of the high frequency, in fact, we are all of us: that savers who rely in managing their money in banks, mutual funds, insurance companies and whose investment strategies are overwhelmed by HFT predators."] *Translations by Google.*

["Themis Trading LLC Joseph Saluzzi: Masters in Business"](#)

Barry Ritholtz interviews Joseph Saluzzi, Bloomberg Radio, March 2, 2015

"Why did the limit order books that we talked about before just disappear? It's not really real liquidity. It's kind of phantom liquidity."

["This High-Speed Trader Says Thanks, Regulators"](#)

Ari Rubenstein, Wall Street Journal, April 23, 2015

"The Securities and Exchange Commission recently proposed a new rule requiring that all off-exchange trading firms become members of the Financial Industry Regulatory Authority (Finra), an industry-funded regulator of brokers that the commission oversees. SEC Chairman Mary Jo White said the proposed rule, once finalized and implemented, 'would significantly strengthen regulatory oversight' of high-frequency trading firms."

["The problem with high frequency trading"](#)

Felix Salmon, BBC Radio, October 6, 2012

"But if you look at what's happened over the past five years, since 2007, the benefits of high-frequency trading have pretty much plateaued. And the downsides are becoming more and more obvious."
See also ["The Problems of HFT, Joe Stiglitz edition"](#) (April 16, 2014).

["Cramer Slams High-Speed Trading"](#)

Drew Sandholm, CNBC, September 18, 2012

(Includes excerpts from "Mad Money with Jim Cramer")

"To me, right now, the high-speed traders are this generation's equivalent of the German machine guns that mowed down British soldiers by the thousands and the people being annihilated by the traders? That's you, the average investor, just trying to using stocks to save some money as generations have before you."

["Turbo-Aktienhändler: 'Dann wird geschossen'"](#) ("Turbo Stock Trader: 'Then is shot'")

Christoph Scheuermann, Spiegel Online, August 23, 2013

"On one of those crazy days was a lot of money lost, 'because an algorithm is haywire,' as Breuer says. The algorithm [bit] like a rabid ferret. Only after seven minutes, they were able to bring it under control, but it was too late." ([Google Translate](#))

["Schwab Statement on High-Frequency Trading"](#)

Charles Schwab, Chairman, and Walt Bettinger, CEO, Charles Schwab Corporation, April 3, 2014

"High-frequency traders are gaming the system, reaping billions in the process and undermining investor confidence in the fairness of the markets. It's a growing cancer and needs to be addressed."

["The \(Questionable\) Legality of High-Speed 'Pinging' and 'Front Running' in the Futures Markets"](#)

Gregory Scopino, Connecticut Law Review, February 2015

"HFT firms might arguably be the fastest sharks swimming in the oceans of financial data, but the CFTC and private plaintiffs might have nets—in the form of relevant statutory and regulatory provisions—capable of catching them"

["Algorithmic Surrealism: A slow-motion guide to high frequency trading"](#)

Brett Scott, June 17, 2015

"The purpose of this piece, though, is not necessarily to convince you on whether or not HFT is a good or bad thing. Rather, it is to provide some frames through which to look at the phenomenon, and through which to understand the debates and news stories that will undoubtedly continue to be written about it in the years ahead."

["The Spider and the Fly"](#)

Rajiv Sethi, August 3, 2013

"If one wants to argue that the new organization of markets has been beneficial to investors, one needs to make the case that the costs of financial intermediation in the aggregate have gone down. Smaller bid-ask spreads have to be balanced against the massive increase in volume, the profits of the new market makers, and most importantly, the costs of high-frequency trading."

See also ["The Risk and Reward in High Frequency Trading"](#) (December 7, 2012) and ["The New Market Makers"](#) (June 4, 2010).

["Superfluous Financial Intermediation"](#)

Rajiv Sethi, April 6, 2014

"[A]n arms race among intermediaries willing to sink significant resources into securing the slightest of speed advantages must ultimately be paid for by investors."

["The Trader as Scapegoat"](#)

Rajiv Sethi, New York Times, April 28, 2015

"If regulators and prosecutors are serious about enforcement of securities laws, they should focus on the largest players in the fragmented markets for stocks and not on an individual, acting alone, who managed to fool an algorithm."

["A Tax to Kill High Frequency Trading"](#)

Lee Sheppard, Forbes.com, October 16, 2012

"The United States should adopt a financial transactions tax (FTT) to kill high frequency trading (HFT) by removing the juice from this pernicious practice."

["The danger of high-frequency traders: Why critics fear HFTs are undermining markets, one penny at a time"](#)

Chris Sorensen, *Maclean's*, October 16, 2013

"Of particular concern for securities regulators is whether all of this light-speed trading has increased the volatility of equity markets, contributing to reduced investor confidence. In addition to the "flash crash," there have been a growing number of painful stock market glitches in recent years that were either related to, or exacerbated by, computers run amok."

["Quick View: Twitter hack shows tech dangers"](#)

Philip Stafford, Financial Times, April 24, 2013

"As the UK government-backed Foresight report into computer-based trading highlighted, one of the dangers within all automated systems lies in what is known as a positive feedback loop, in which a small change in computer trading feeds back on itself, triggering a bigger change, which in turn feeds back on itself, and so on. The process amplifies volatility, especially in interlinked markets."

["Quick View: Eurex caught out"](#)

Philip Stafford, Financial Times, February 20, 2014

"As we have seen with outages around the world, too often the complex, subsecond interlinked markets feel very brittle. One of the great unknowns of the market infrastructure world is whether enough resources are being devoted to the technology to withstand shocks."

["An ode to high-frequency trading"](#)

Benn Steil, Financial Times, September 13, 2010

"Those magnificent men and their trading machines,
They trade up, diddly, up, up!
They trade down, diddly, down down!
They stuff lots of quotes, then they empty the screens,
With their up, diddly up, up!
And their down, diddly, down down!"

["Fair Play Measured in Slivers of a Second"](#)

James B. Stewart, New York Times, July 12, 2013

"Two seconds may not seem like much, but for high-speed traders with supercomputers, it's plenty."

["Barclays Suit Sheds Light on Trading in Shadows"](#)

James B. Stewart, New York Times, July 5, 2014

"The high-frequency trading firms have broadly defended their practices by arguing that they bring liquidity to the market. And there's no doubt that the rise of electronic trading, much of it conducted by high-frequency traders, has lowered trading costs and narrowed the spread between bid and ask prices, which benefits investors. But it's hard to discern what benefit these firms provide when they manage to insert themselves between buyers and sellers for a mere nanosecond."

["Tapping the Brakes: Are Less Active Markets Safer and Better for the Economy?"](#)

Joseph E. Stiglitz, Federal Reserve Bank of Atlanta 2014 Financial Markets Conference, April 15, 2014
"As we briefly noted earlier, there are a variety of ways by which HFT results in sophisticated versions of front running. Co-location, the fact that HFT can pay to get access to business news releases before others, and have been given other advantages has resulted in an unlevel playing field, allowing them to garner rents for themselves at the expense of others. Moreover, as we noted earlier, as confidence in markets erodes, transactions shift out of markets, and the advantages of markets (including their transparency) are lost." See also ["The Problems of HFT, Joe Stiglitz edition"](#) (April 16, 2014).

["New Ways to Crash the Market"](#)

James Surowiecki, New Yorker, May 28, 2015

"The problem isn't the robots per se but the uses we've put them to. As Kirilenko told me, 'Automation should, in principle, make markets cheaper, faster, and more accessible.' Indeed, markets today incorporate new information faster than ever before. Yet they are also fundamentally less stable, and more prone to sudden and inexplicable breakdowns. A 2014 study of the impact of algorithmic trading across forty-two global stock markets found that it made the markets more liquid and more efficient but also more volatile. Even more striking, a 2013 study of commodity markets found that, over the years, these markets have become increasingly self-reflexive: sixty to seventy per cent of price changes are driven not by new information from the real world but by 'self-generated activities.' Markets, in other words, are moving themselves much of the time. That may be how Navinder Sarao got rich. It's also how we've arrived at a situation where a trillion dollars can vanish in a matter of minutes, even though the real world hasn't changed at all."

["Welcome to a wild world of robot investing"](#)

Gillian Tett, Financial Times, August 27, 2015

"Never mind that the Dow Jones index plunged by 1,000 points in just a few minutes on Monday morning (before later rallying). What was more startling was that the share price of stalwart American companies such as Apple, Home Depot or General Electric gyrated even more dramatically in minutes. Meanwhile, the value of some exchange traded funds tumbled more than 30 per cent."

["How humans can wrest control of the markets back from computers"](#)

Gillian Tett, Financial Times, October 22, 2015

"Investors have had plenty of reasons to worry about oil prices this year. Now there is another: Timothy Massad, chairman of the US Commodity Futures Trading Commission, revealed on Wednesday that there have been 35 bizarre 'flash crashes' in American oil markets this year."

["How NYSE, Nasdaq profit off 'Flash Boys'"](#)

Jonathan M. Trugman, NY Post, April 6, 2014

"At the end of the day, fundamentals rule, but when exchanges that are in charge of oversight enable and are aiding, abetting and profiting by giving share pricing data early to preferred customers, the game really is rigged. The exchanges are the real 'Flash Boys.' It's time to clean them up."

["Thank the 'robots' for Wall Street's wild ride"](#)

Jonathan M. Trugman, NY Post, August 29, 2015

"Was last week's manic market roller coaster a sign of what to expect in the fall, when markets historically get skittish? August started off by brutally punishing investors, but last week's stock-market swings were surely for the record books. High-speed trading on thin August volume produced unprecedented market volatility."

["Reign of the High-Frequency Trading Robots"](#)

Wallace Turbeville, U.S. News and World Report, October 18, 2013

"HFT traders often do supply executable price quotes, which superficially increase liquidity. True liquidity, however, comes when offers can be relied upon, allowing investors to predict whether the transactions they seek can be completed within their preferred price range. Because HFT traders can morph from providers to consumers of liquidity whenever the herd abruptly shifts from buy to sell, they create uncertainty rather than predictability."

See also ["Are Academics for Hire Influencing the HFT Debate?"](#) (March 25, 2013), ["High Frequency Trading"](#) (March 8, 2013), and ["The Real Cost of High Frequency Trading"](#) (April 14, 2014).

["Hurrying Into the Next Panic?"](#)

Paul Wilmott, New York Times, July 28, 2009

"Thus the problem with the sudden popularity of high-frequency trading is that it may increasingly destabilize the market."

["When Will Retail Investors Call It Quits?"](#)

Jason Zweig, Wall Street Journal, August 2, 2012

"So much for the reassurances from regulators and stock-exchange officials that a repeat of the 'flash crash' is impossible."

Books and Documentaries

["Broken Markets: How High Frequency Trading and Predatory Practices on Wall Street are Destroying Investor Confidence and Your Portfolio"](#)

Sal L. Arnuk and Joseph C. Saluzzi (2012)

"The market has been hijacked. An evolved class of leveraged short-term, high-speed traders, sometimes called *high frequency traders*, who trade massive amounts of shares based on proprietary algorithms, has eclipsed other types of traders."

See also the [Themis Trading Blog](#), where Sal Arnuk and Joe Saluzzi write some of the most thoughtful commentary on the markets anywhere.

["The Problem of HFT"](#)

Haim Bodek (2013)

"With automation, the US equities markets had evolved into a vast complex machine, one that was purposefully well-tuned to the nuances of HFT scalping strategies. Modern HFT wasn't a paradigm shift because its innovations brought new efficiencies into the marketplace. HFT was a paradigm shift because its innovations proved that anti-competitive barriers to entry could be erected in the market structure itself to preference one class of market participant above all others." See also ["SEC Charges Direct Edge Exchanges With Failing to Properly Describe Order Types"](#); ["CEO Podcast: Haim Bodek, Author of The Problem with High Frequency Trading."](#)

["The Market Structure Crisis: Electronic Stock Markets, High Frequency Trading, and Dark Pools"](#)

Haim Bodek and Stanislav Dolgoplov (2015)

"A truly national debate has been galvanized around the once obscure topic of market structure. As a result, the regulatory framework governing the architecture of securities market is changing, and our industry should expect the electronic marketplace to go through even more transformations."

[Les Nouveaux Loups de Wall Street](#) ["The New Wolves of Wall Street"]

Canal+ (2015)

"Certains estiment que la Bourse est désormais truquée.... Des États-Unis (New York, Connecticut, New Jersey, Chicago) à la Grande-Bretagne (Londres), en passant par les Pays-Bas (Amsterdam) et la France, Ali Baddou nous emmène au cœur du système à la rencontre de ces nouveaux loups de Wall Street qui gouvernent désormais le monde de la finance." ["Some believe that the stock market is rigged now From the US (New York, Connecticut, New Jersey, Chicago) in Great Britain (London), via the Netherlands (Amsterdam) and France, Ali Baddou takes us to the heart of the system to meet these new wolves of Wall Street, which now govern the world of finance." *Google Translate.*]

["The Payoff"](#)

Jeff Connaughton (2012)

"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."

["Krach machine: Comment les traders à haute fréquence menacent de faire sauter la bourse"](#) ["Crash machine: How high frequency traders threaten to blow up the stock exchange"]

Lelièvre, Pilet (2013)

"Qui sont ces traders qui agissent pratiquement à la vitesse de la lumière?" ["Who are these traders who

operate at nearly the speed of light?"]

["Crapshoot Investing"](#)

Jim McTague (2011)

"The stock market has changed radically since 2005, yet few persons realized the greatness of the seismic shift until May 6, 2010, when the major averages collapsed over the course of 10 minutes."

["Dark Pools: High-Speed Traders, A.I. Bandits, and the Threat to the Global Financial System"](#)

Scott Patterson (2012)

"Insiders were slowly realizing that the push-button turbo-trading market in which algos battled algos inside massive data centers and dark pools at speeds measured in billionths of a second had a fatal flaw." See also ["SEC Charges Direct Edge Exchanges With Failing to Properly Describe Order Types"](#).

["Finance Folle: L'Attaque des Robots Traders"](#) ["Finance Madness: Attack of the Robot Traders"]

TV Monde 5 (2012)

"Developed by mathematicians, robots built on powerful algorithms perform thousands of orders in the market in just a few seconds. This documentary, produced by TV5 Monde, exposes this contemporary phenomenon in the world of finance."

["Ghost Exchange"](#)

Arbitrage Pictures (2012)

Directed by Camilla Sullivan

"I think the flash crash sent a clear message that there's something wrong in our system."

["Backlight - Money and Speed: Inside The Black Box"](#)

VPRO, Dutch public broadcasting (2011)

Directed by Marije Meerman.

Produced by Mariska Schnider for the series "Backlight."

"On May the 6th 2010, at 1400 hours, 42 minutes, and 44 seconds, the U.S. stock markets go into free fall. The Dow Jones takes the fastest and most dramatic nosedive in its history, an event that will be remembered as the 'Flash Crash.'"

["Snel Geld"](#) ["Fast Cash"]

VPRO, Dutch public broadcasting (2015)

Directed by Hansje van de Beek and Stefan Heijndael

"High Frequency Trading is hotly debated since the book 'Flash Boys' from Michael Lewis. With his accusation that the markets are rigged whistle-blower Brad Katsuyama put high frequency trading in the public spotlight. In this visualized radio-documentary VPRO's Argos, a Dutch public research program, investigates the money making techniques of high frequency trading and looks into the 'Dutch Flash Boys case' concerning a test trade which sparked the debate in the Netherlands. How fast must trading go? And how fair is buying shares with scalpers watching your trades?"

["Wall Street Code"](#)

VPRO, Dutch public broadcasting (2013)

Directed by Marije Meerman.

Produced by Jenny Borger, Helen Goosens, and Marie Schutgens for the series "Backlight."

"Super-quick computers and advanced mathematic formulas have largely taken over trading on the financial markets from human beings. Algorithms, which seem to have a life of their own. Algorithms secretly lie waiting for the moment that your Apple share or your pension money gets in the market."

"Flash Boys" by Michael Lewis

["Flash Boys"](#)

Michael Lewis (2014)

"As they worked through the order types, the Puzzle Masters created a taxonomy of predatory behavior in the stock market. Broadly speaking, it appeared as if there were three activities that led to a vast amount of grotesquely unfair trading. The first they called electronic front-running - seeing an investor trying to do something in one place and racing ahead of him to the next (what had happened to Katsuyama when he traded at RBC). The second they called rebate arbitrage - using the new complexity to game the seizing of whatever legal kickbacks, called rebates within the industry, the exchange offered without actually providing the liquidity that the rebate was presumably meant to entice. The third, and probably by far the most widespread, they called slow-market arbitrage. This occurred when a high-frequency trader was able to see the price of a stock change on one exchange and pick off orders sitting on other exchanges before those exchanges were able to react. This happened all day, every day, and very likely generated more billions of dollars a year than the other strategies combined." (From an adaptation published in [The New York Times](#).)

60 Minutes

["Is the U.S. stock market rigged?"](#)

Steve Kroft, CBS News, March 30, 2014

"It's crazy that it's legal for some people to get advance news on prices and what investors are doing. It's just nuts. Shouldn't happen."

Reviews

["Flash Boys: Michael Lewis muscles into the dodgy world of high-frequency trading"](#)

Simon Hopt, The Globe and Mail, April 4, 2014

"Lewis's primary achievement is in making the opaque world of high-frequency trading (HFT), in which computer algorithms execute millions of trades within seconds, accessible and sometimes even thrilling to the lay reader. He argues that HFT creates a 'class system, rooted in speed, of haves and have-nots,' in which deep-pocketed, technologically astute and savvy traders can, in a practice known as 'front-running,' sniff out others' trade orders and then insert themselves between sellers and buyers to make a profit without any risk."

["Scalpers, Inc."](#)

John Lanchester, London Review of Books, June 5, 2014

"Flash Boys is a number of things, one of the most important being an exposition of exactly what is going on in the stock market; it's a one-stop shop for an explanation of high-frequency trading (hereafter, HFT). The book reads like a thriller, and indeed is organised as one, featuring a hero whose mission is to solve a mystery."

["Hobbling Wall Street Cowboys"](#)

Janet Maslin, New York Times, April 1, 2014

"['Flash Boys'] also explores the breakup of big, central stock exchanges into many small ones; the impossibility of investors' knowing exactly what is being done with their money; and the immense new opportunities for skimming, kickbacks, secret fees and opacity that the new system has spawned. Because Mr. Lewis is at the helm finding clear, simple metaphors for even the most impenetrable

financial minutiae, this tawdry tale should make sense to anyone. And so should its shock value. 'Flash Boys' is guaranteed to make blood boil."

["Flash Boys': Michael Lewis does it again"](#)

Steve Pearlstein, Washington Post, April 12, 2014

"[I]n 'Flash Boys,' Lewis reveals how a new crop of investment firms has conspired with the big banks and the stock exchanges to use high-speed computers and complex software algorithms to skim pennies from the real investors who provide equity capital to the economy."

["High on Speed"](#)

James Surowiecki, New York Review of Books, July 10, 2014

"With his new book, Flash Boys, Michael Lewis has made a story that very few people in America had known, or cared, anything about - the rise of high-frequency trading on Wall Street - into the object of national outrage."

CNBC

Michael Lewis and a central figure in "Flash Boys," Brad Katsuyama, debated a stock exchange executive on CNBC shortly after "Flash Boys" was published. Highlights of "The fight that stopped NYSE trading" [here](#). The full debate [here](#).

Interviews

["Michael Lewis calls Wall St. 'unfair playing field'"](#)

Matt Lauer interviews Michael Lewis, The Today Show, April 1, 2014

"I'm following the story of people - actually of Wall Street insiders - trying to figure out how this stock market works because they themselves don't understand."

["Michael Lewis discusses his latest book: 'Flash Boys: A Wall Street Revolt'"](#)

Charlie Rose interviews Michael Lewis, March 31, 2014

"The rigging of markets is a response to a decline in the natural usefulness of the institutions at the heart of capitalism."

["Michael Lewis on High-Frequency Trading and Markets"](#)

Stephanie Ruhle and Erik Schatzker interview Michael Lewis, Bloomberg, April 2, 2014

"Big pension fund managers and mutual fund managers saw when they tried to execute big orders - oh my god - it's like someone knows I want to buy before I buy."

["Open Phones on Flash Boys"](#)

Peter Slen interviews Michael Lewis, C-SPAN, April 5, 2014

"Imagine a ticket scalper, someone who figures out that the show's going to be sold out, runs up, buys tickets at the box office price and turns around and sells them at double the price to people who walked up to see the show."

Other Interviews

["High Speed Reality Check"](#)

Aaron Sorkin, Joe Kernan, Becky Quick interview Joe Saluzzi of Themis Trading, CNBC, March 31, 2014
"The system is dominated by scalpers....I guarantee you once you read this book your blood will boil."

["High Frequency Trading Neither Good or Bad: Arnuk"](#)

Stephanie Ruhle and Erik Schatzker interview Sal Arnuk of Themis Trading, Bloomberg, March 31, 2014
"The system is set up to insert the maximum number of intermediaries between natural buyers and natural sellers."

"Flash Boys": Supporting Evidence

Much of the research in this bibliography unequivocally supports the central narratives of Michael Lewis's "Flash Boys": To the disadvantage of long-term investors, high frequency trading firms front-run demand, manipulate market structure defects, manipulate prices, post phantom quotes, and exert improper influence on stock exchanges. The following is a recap of just some of the evidence supporting these points from institutions like the SEC, Princeton, the University of Chicago, Nasdaq, Northwestern University and industry regulator FINRA, among many others.

The [Australia Industry Super Network](#) estimated that high frequency traders cost long-term Australian investors an average A\$1.6 billion a year. [Baron et. al.](#) (2014) found that "HFTs have strong incentives to take liquidity and compete over small increases in speed in an industry dominated by a small number of incumbents earning high and persistent returns." [Boni et. al.](#) (2012) found that excluding high frequency traders from a market center improved it, and led to lower volatility, less front running, and higher execution quality for institutional traders. [Boulton et. al.](#) (2012) discovered that "seemingly fleeting events, such as the flash crash, can have dramatic and lingering effects on shareholder wealth and market quality." [Budish et. al.](#) (2013) concluded "that the [HFT speed] arms race is socially wasteful – a prisoner's dilemma built directly into the market design – and that its cost is ultimately borne by fundamental investors via wider spreads and thinner markets." [Van Kervel and Menkveld](#) (2016) studied Swedish equities and concluded that "HFTs seem to run on the most informed orders. HFT [front running] on institutional orders does not necessarily improve market quality. One could argue that prices become more efficient in the short run. HFT trading in the same direction as informed investors makes prices reveal private information more quickly. The worrisome side effect is that, in the long run, prices could become less efficient." [Malinova and Park](#) (2015) analyzed Canadian equities data and found that "Overall, our analysis indicates that after, say, trading with a buyer, market-makers cancel their sell orders quickly and submit aggressive buy orders." [Korajczyk and Murphy](#) (2015) looked at Canadian equities and found that it is "possible that an HFT 'frontruns' these large orders, in that the HFT buys (sells) ahead of a large stressful buy (sell) and subsequently sells to (buys from) the large trader at a higher (lower) price."

[Clark-Joseph](#) (2013) found that "HFTs appear to trade ahead of predictable demand innovations...[and] HFTs could have a destabilizing influence on prices if suitable positive-feedback mechanisms exist." [Ding et. al.](#) (2013) compared the relative speeds of investor data feeds to the exchange proprietary data feeds typically used by high frequency traders and found a substantial advantage for the proprietary data feeds. Industry regulator [FINRA](#) (2014) alleged a firm's high frequency trading customers employed "aggressive, potentially destabilizing trading strategies in illiquid securities." [Gao and Mizrach](#) (2013) found that high frequency traders are more profitable when they trade against long-term investors than when they trade with other high frequency firms. [Wah](#) (2015) studied U.S. stock market data and

estimated "that total potential profit from latency arbitrage opportunities in S&P 500 ticker symbols was approximately \$3.03 billion in 2014."

[Hirschey](#) (2013) has "evidence consistent with HFTs being able to anticipate order flow from other investors." [Johnson et. al.](#) (2013) "uncovered an explosion of UEEs [ultrafast extreme events] starting in 2006, just after new legislation came into force that made high frequency trading more attractive." [Kim and Murphy](#) (2013) found market spreads were much worse than have been reported. [Kirilenko and Lo](#) (2013) concluded that "In contrast to a number of public claims, high frequency traders do not as a rule engage in the provision of liquidity like traditional market makers." [McInish and Upson](#) (2012) "show empirically that latency differences allow fast liquidity suppliers to pick off slow liquidity demanders at prices inferior to the NBBO" and wrote that "the ability of fast liquidity suppliers to use their speed advantage to the detriment of slow liquidity demanders...unambiguously lowers market quality." [Menkveld and Zoican](#) (2014) found that "a faster market implies more interaction among HFTs, i.e., their market participation increases and, more importantly, transaction cost for 'low frequency' investors increases as a result."

[Nanex](#) (2013) detailed episodes where high frequency traders paid for market-moving information worth millions ahead of other investors. [Nanex](#) (2014) analyzed the impact of one trader's order and found "sell orders simply disappeared before the exchanges processed his buy order." [Nasdaq](#) (2012) "observed that upon partial execution of a routable order at NASDAQ...market participants often react to the order by cancelling their orders on other markets and entering new orders at inferior prices." (In 2014, a senior executive of a high frequency market maker, who was also head of an industry lobbying group at the time, wrote "If I quote on 8 exchanges and get hit on one, I will update 16 prices. That is main reason for high [cancel] rates," strong evidence for Nanex's and Nasdaq's points; he later confessed "market makers offer more liquidity than they're prepared to trade in one go.") [Norges Bank Investment Management](#) (2013), one of the largest funds in the world with nearly \$1 trillion under management, concluded that "issues of concern to large, long-term investors more deserving of attention include — Anticipation of large orders by some HFTs leading to potential adverse market impact — Transient liquidity due to high propensity for HFTs to rapidly cancel quotes real-time — Un-level playing field amongst market makers from low latency ultra HFT strategies."

[Pragma Securities](#) (2012) examined U.S. stock trading in 2011 and 2012 and concluded that "high frequency traders' ('HFTs') profits come at the expense of investors." The [Quantitative Services Group](#) (2010) examined U.S. equity data and reported that "Sophisticated pattern recognition algorithms now present a real return burden to active equity managers." [Rogers et. al.](#) (2015) found that the SEC provided corporate filings to high-speed traders before providing them to the public. [Tong](#) (2013) found "strong evidence that HFT increases the trading costs of institutional investors." [Toulson](#) (2013) examined European equities and found that HFT firms reacted to asset manager orders by cancelling their own orders and trading in front of the asset manager.

The **United States Securities and Exchange Commission** (2014) [fined a high frequency trading firm](#) for manipulating "the closing prices of thousands of NASDAQ-listed stocks" over a six month period; it levied a [record fine against a stock exchange](#) in 2015 for giving "information about order types only to some members, including certain high-frequency trading firms that provided input about how the orders would operate." [Van Kervel](#) (2014) found that "high-frequency traders can observe the first part of the trade and quickly cancel outstanding limit orders on other venues before the second part of the trade arrives." [Ye et. al.](#) (2013) concluded that speed improvements do not improve spreads but do increase cancellations and volatility.

Government Reaction to HFT

Central Banks

["The Growth of High-Frequency Trading: Implications for Financial Stability"](#)

William Barker and Anna Pomeranets, Bank of Canada, June 2011

"[W]hile the growth of HFT has been associated with market-wide benefits, it also magnifies certain risks, which may cascade into financial systems and lead to financial instability."

["Recent Changes in the Resilience of Market Liquidity"](#)

Lael Brainard, Governor, Board of Governors of the Federal Reserve System, July 1, 2015

"Competition from high-frequency trading in a particular market may reduce the attractiveness of that market for traditional (manual) traders or slower automated traders, leading to a progressive shift in the composition of market participants toward high-frequency traders (HFTs) over time. This shift could be important to the extent that HFTs may have more limited capacity to support liquidity resilience since, on average, HFTs appear to trade with smaller inventories and lower capital than traditional traders. Although having less inventory and capital reduces the cost of trading, it also means that markets increasingly dominated by HFTs may be less able to absorb large shocks. Thus, liquidity may be sufficient and relatively cheap on normal trading days, but it may not be deep enough to prevent large price swings when demand for liquidity is significantly above the norm."

["How to Keep Markets Safe in the Era of High-Speed Trading"](#)

Carol Clark, Federal Reserve Bank of Chicago, October 2012

"A number of recent technology-related snafus have focused attention on high-speed trading and affected investor confidence in the markets. These incidents and the resulting losses highlight the need for risk controls at every step of the trading process."

["Market Structure, incentives, and fragility"](#)

Carol Clark, Federal Reserve Bank of Chicago, March 2014

"Certainly, HST [high speed trading] poses operational risks to the market due to the rate at which large, unintended positions can accumulate. There is also the possibility HST may result in positive or negative feedback loops caused by a runaway algorithm triggering other algorithms or by numerous HST firms utilizing trading models that do not accurately assess and respond to changing market conditions. The myriad of technologies that support HST also result in 'systems that are robust yet fragile.' Failure in one of many parts may have unexpected knock-on effects in others."

["High-frequency trading in the foreign exchange market"](#)

Guy Debelle, Reserve Bank of Australia, October 12, 2011

"While HFT generates increased activity and narrower spreads in normal times, it may have reduced the resilience of the system as a whole in stressed times by reducing the activity of traditional market participants who may have otherwise been an important stabilising presence in volatile environments."

["CFTC Concept Release on Risk Controls and System Safeguards for Automated Trading Environments"](#)

Charles Evans, President and CEO, Federal Reserve Bank of Chicago, December 2013

"[W]e believe it would be prudent to require consistent risk controls for ATs and high frequency trading (HFT) systems due to the speed at which each of these systems can amass large, unintended positions....We also note that many industry and regulatory groups have devised best practices for HFT. Nevertheless, many firms do not fully implement these best practices because they are not required to do so. We believe it would be beneficial for the Commission to work with the industry to define best practices for HFT and to communicate penalties for non-compliance with those best practices."

["European Commission's Public Consultation on the Review of the MiFID - Eurosystem Contribution"](#)

European Central Bank, February 2011

"In the last few years, automated trading, and in particular High-Frequency Trading (HFT), has experienced strong growth. Such a development may trigger a number of risks for orderly trading and for financial stability."

["Opinion of the European Central Bank of 13 December 2012 on high frequency trading"](#)

European Central Bank, December 13, 2012

"[A]lthough AT practices [including high frequency trading] may have legitimate purposes, they might also jeopardise the liquidity and efficiency of financial markets, particularly in times of market stress, as they could disturb the normal functioning of the market and increase volatility, which would be contrary to the public interest."

["Race to Zero"](#)

Andrew Haldane, Bank of England, July 8, 2011

"Far from solving the liquidity problem in situations of stress, HFT firms appear to have added to it. And far from mitigating market stress, HFT appears to have amplified it. HFT liquidity, evident in sharply lower peacetime bid-ask spreads, may be illusory. In wartime, it disappears."

["Recommendations for Equitable Allocation of Trades in High Frequency Trading Environments"](#)

John McPartland, Federal Reserve Bank of Chicago, July 10, 2014

"Rather than propose solutions that might preclude specific HFT strategies, we propose to simply change the economics of the trading environment by modifying the criteria of order allocation priority and by discouraging certain questionable industry practices to strike a more equitable balance between the high frequency trading community and the investment management community."

["High-frequency trading and market implications - an assessment from a central bank perspective"](#)

Dr. Joachin Nagel, Deutsche Bundesbank, July 4, 2012

"There are increasing signs, for example, that, especially in volatile market situations, HFT might prove to be tricky - in the sense of further destabilising the market."

["Electronic trading and financial markets"](#)

Kiyohiko Nishimura, Bank of Japan, November 29, 2010

"Although the expansion of electronic trading has brought many positive effects, as noted, it also has its own negative side with respect to the proper functioning of financial markets."

["Challenges Posed by the Evolution of the Treasury Market"](#)

Simon Potter, Federal Reserve Bank of New York, April 13, 2015

"That said, it is possible that the dominance of electronic and automated trading and the changing composition of participants in the Treasury market have interacted with changes to dealer behavior—whether the result of regulatory incentives or other reasons—in a manner that makes unusual intraday price moves more probable....recurring periods of heightened and unexplained volatility – especially if prompted by little new information, as with the event window on October 15—could prompt end-investors and market makers to question the superior liquidity of the Treasury market and perhaps hamper the critical roles the market serves."

["Structure and Liquidity in Treasury Markets"](#)

Jerome H. Powell, Governor, Board of Governors of the Federal Reserve System, August 3, 2015

"Technology and greater competition have led to lower costs in many areas of our economy. At the same

time, slower traders may be put at a disadvantage in this environment, which could cause them to withdraw from markets or seek other venues, thus fracturing liquidity. And one can certainly question how socially useful it is to build optic fiber or microwave networks just to trade at microseconds or nanoseconds rather than milliseconds. The cost of these technologies, among other factors, may also be driving greater concentration in markets, which could threaten their resilience."

Regulators

["Keynote Address by Commissioner Sharon Y. Bowen before ISDA North America Conference"](#)

Sharon Y. Bowen, Commission, U.S. Commodity Futures Trading Commission, September 15, 2015

"In other words, we want to make sure that, before you turn on an algorithm, you have taken measures to both prevent the algorithm from malfunctioning and have processes in place to take the algorithm offline if it goes haywire. We need algorithmic traders to take these precautions because we want to ensure that users of this technology do not act in ways that manipulate the markets or cause undue danger to the broader financial system, other investors, or consumers."

["Market Structure Enforcement: Looking Back and Forward"](#)

Andrew Ceresney, Director, Division of Enforcement, U.S. SEC, November 2, 2015

"Let me focus first on the national stock exchanges. In the entire history of the Commission prior to fiscal year 2012, the SEC had never imposed a single civil penalty on a national stock exchange. Since fiscal year 2012, the Commission has brought 7 proceedings involving 9 different exchanges and has imposed more than \$39 million in civil penalties....This brings me to the last of the four threats that I mentioned: high volume manipulation. Detecting, investigating, and bringing cases against those responsible for market manipulation or abusive trading schemes is a core responsibility and priority of the SEC."

["New Species: How Market Participants Have Evolved in Financial Ecosystems"](#)

Bart Chilton, Commissioner, U.S. Commodity Futures Trading Commission, February 1, 2011

"Mini-flash crashes occur all the time, too. More than once last year in futures markets and several times in stocks, runaway robotic programs disrupted markets and cost people money. One company lost a million dollars in the oil market in less than a second when an algo ran wild."

["OSC head leans to the negative about high-frequency trading"](#)

Boyd Erman, The Globe and Mail, August 20, 2012

Interview of Howard Wetston, Chairman, Ontario Securities Commission (Canada)

"We ask ourselves the fundamental question: Is this type of trading actually consistent with what we expect of financial services and financial markets?"

["New rules for high-frequency trading"](#)

Federal Financial Supervisory Authority (Germany), November 22, 2012

"High-frequency trading has increased the speed and complexity of trading. This is associated with risks: for example, large order volumes may place a heavy burden on trading systems. Algorithms may also react to market events and trigger additional algorithms as a result, which may in turn trigger even more algorithms (cascade effect), leading to an increase in volatility."

["Speed limit for high-frequency trading - Federal Government adopts legislation to avoid risks and prevent abuse in high-frequency trading"](#)

Federal Ministry of Finance (Germany), September 26, 2012

"Computer-based high-frequency trading using algorithms poses multiple risks of extreme and irrational

price fluctuations, overloaded trading systems and new opportunities for abuse."

["France wants tougher HFT regulation"](#)

Jeremy Grant and Philip Stafford, Financial Times, December 19, 2011

Press conference of Thierry Francq, secretary-general of Autorité des Marchés Financiers (France)

"Mr Francq called for the creation of a 'preventive framework' of new market rules to 'minimise the risk of HFT, and that means probably a rather harsh slowdown of this technique.'"

See also ["Issues related to MiFID II"](#) .

["Keynote speech by Jean-Pierre Jouyet"](#)

Jean-Pierre Jouyet, Chairman of the Autorité Des Marchés Financiers (France), February 13, 2012

"More generally, high-frequency algorithmic trading can aggravate the instability of a market by provoking unfounded price oscillations or anomalies arising from the interaction of two algorithms, as we saw with the Wall Street flash crash of May 6th 2010."

See also ["Issues related to MiFID II"](#) .

["Remarks of Chairman Timothy Massad before the Conference on the Evolving Structure of the U.S. Treasury Market"](#)

Timothy Massad, Chairman, U.S. Commodity Futures Trading Commission, October 21, 2015

"In just this year, for example, there were about 35 events meeting this definition [for a flash crash or flash smash] involving the WTI crude oil contract alone. We also found quite a few having to do with other contracts in the last several years, including corn and gold. The second chart shows the number of these events for various contracts. Movements of a magnitude similar to Treasuries on October 15th were not uncommon in many of these contracts. In fact corn, the largest grain futures market, averaged more than five such events per year over the last five years."

["ASIC Chairman's address to FINSIA Conference 2012"](#)

Greg Medcraft, Chairman, Australian Securities and Investments Commission, October 10, 2012

"And while some say high-frequency trading provides liquidity, I know some very senior bankers that privately describe it as providing only 'phantom liquidity.'"

["Remarks Before the Investment Company Institute's General Membership Meeting"](#)

Mary L. Schapiro, Chairman, U.S. Securities and Exchange Commission, May 6, 2011

"High frequency traders turned what was a very down day for many investors into a very profitable one for themselves by taking liquidity rather than providing it."

["Algorithmic Trading Briefing Note"](#)

Senior Supervisors Group, April 2015

[The Canadian Office of the Superintendent of Financial Institutions, the European Central Bank Banking Supervision, the French Prudential Control and Resolution Authority, the German Federal Financial Supervisory Authority, the Bank of Italy, the Japanese Financial Services Agency, the Netherlands Bank, the Bank of Spain, the Swiss Financial Market Supervisory Authority, the United Kingdom's Prudential Regulatory Authority, and U.S. Office of the Comptroller of the Currency, the U.S. Securities and Exchange Commission, and the U.S. Federal Reserve.]

"Indeed, unexpected events linked to algorithmic and high frequency trading have caused significant volatility and market disruption, leading to heightened debate around the risks these activities pose to the functioning of global markets. The complexity of market interactions among HFT firms and other market participants increases the potential for systemic risk to propagate across venues and asset classes over very short periods of time."

["Remarks before Trader Forum 2014 Equity Trading Summit"](#)

Kara M. Stein, Commissioner, U.S. Securities and Exchange Commission, February 6, 2014

"Firms with direct access to the markets and execution venues should be required to have detailed procedures for testing their systems to ensure that they don't cause market failures. Systems should be reliable, so that anticipated failures are rare. Testing should be thorough. Data should be verified. But systems must also be resilient, so that they can adapt and respond to challenges. Seamless backup systems should be established. Firewalls and trading limits should be clearly defined and coordinated across markets."

["OFR 2013 Annual Report"](#)

U. S. Treasury, Office of Financial Research, December 2013

"Automated trading represents a significant portion of daily equity and foreign exchange volumes and a sizable portion of Treasury market volumes. Given these volumes, high-frequency trading poses several potential financial stability risks, suggesting that closer monitoring may be warranted....high-frequency trading systems may obscure price discovery, exaggerate illiquidity, increase volatility, and contribute to extreme price changes. The initial trigger may be a loss by a large institution that leads to a market disruption, with a cascading effect on markets and market participants. "

["OFR 2014 Annual Report"](#)

U.S. Treasury, Office of Financial Research, December 2014

"Historically, stock markets relied on intermediaries known as market-makers and specialists who are expected to buy and sell a particular stock at a publicly quoted price to maintain fair and orderly markets. Today, their role has significantly diminished as newer market participants, using high-frequency trading strategies, have emerged. Firms using high-frequency trading strategies are an important liquidity source under normal conditions, but do not have an explicit obligation to provide liquidity during times of stress. The so-called flash crash in equity securities on May 6, 2010 is one such example."

["FSOC 2014 Annual Report"](#)

U.S. Treasury, Financial Stability Oversight Council, May 2014

"In the past year, there were several disruptions in market infrastructure systems that are designed to facilitate the transmission of data and support other automated trading systems....The Council also recognizes that alternative trading venues and methods may present operational and other risks by magnifying system-wide complexity. These vulnerabilities may be heightened, particularly in fragmented markets, by high frequency or low latency automated trading activities. As such, regulators should focus not only on centrally-traded products, but also on a broader set of financial products and trading methods that trade off exchanges."

["We need rules to limit the risks of superfast trades"](#)

Martin Wheatley, CEO, Hong Kong Securities and Futures Commission
Financial Times, September 20, 2010

"When a single strategy becomes as dominant as HFT appears to have become - as happened in 1987 with 'portfolio insurance' and as is happening now with HFT - markets become fragile. And this fragility will lead to more shock events such as the 'flash-crash'."

["Enhancing Our Equity Market Structure"](#)

Mary Jo White, Chairman, U.S. Securities and Exchange Commission, June 5, 2014

"An area of particular focus is the use of aggressive, destabilizing trading strategies in vulnerable market conditions, when they could most seriously exacerbate price volatility. While the volatility moderators already put in place impose outside limits on price moves, even moves within those limits can be damaging. Instability arising during a broad market event may simultaneously affect hundreds or thousands of stocks, triggering many trading pauses and reopenings over a short period of time."

Legislators

["Tougher rules to protect investors and curb high-frequency trading"](#)

European Parliament, October 26, 2012

"MEPs also tightened up proposed rules on high-frequency trading."

["MiFID: European Parliament wants safer financial markets"](#)

EPP Group in the European Parliament, September 27, 2012

"The new EU Directive on Markets for Financial Instruments (MiFID) ought to ban destructive speculation on financial markets."

["Harkin: Tax high-speed traders to fill budget hole"](#)

U.S. Senator Tom Harkin interviewed by Ronald D. Orol of MarketWatch, November 29, 2012

"I really don't see any evidence that these high-speed traders add anything to the economy, but they do also create some aberrations in the market that have led to some disturbances."

["Ongoing Market Structure Review"](#)

U.S. Senator Edward E. Kaufman, August 5, 2010

"For example, while speed and efficiency can produce certain benefits, they have also created a micro-arms race that is being waged in our public marketplace by high frequency traders and others."

["Kaufman Delivers Final Senate Floor Speech on Market Structure Issues, High Frequency Trading"](#)

U.S. Senator Edward E. Kaufman, September 28, 2010

"Simply put, technological developments must operate within a framework that ensures integrity and fairness."

See also ["Archived Web Site \(captured November 2010\) of Ted Kaufman \(U.S. Senate, 2009-2010\)"](#).

["Request for Comments Regarding Findings and Recommendations of the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues"](#)

U.S. Senator Carl Levin. April 8, 2011

"Regulations designed to ensure the stability and integrity of our markets must be coordinated across all of the markets, and while the recent coordination by the SEC and CFTC is a useful step, I believe much more needs to be done."

See also ["Statement of Sen. Carl Levin - Subcommittee on Securities, Insurance and Investment"](#).

["Letter to U.S. Commodity Futures Trading Commission Chairman Gary Gensler"](#)

U.S. Congressman Edward J. Markey, September 19, 2012

"The 2010 Flash Crash in equity markets severely damaged confidence and sent a signal to ordinary investors that they are at a disadvantage. If high-frequency traders are now causing similar crashes in the commodity markets, both the investment community and the general public will lose confidence that the markets are working properly." See also [letter to Elisse B. Walter, U.S. Securities and Exchange Commission](#) and ["Markey: Rules of Road Needed for Wall Street's High Speed Trading"](#).

["Senator Jack Reed: Market Disruptions Are 'Wake Up Call' on HFT"](#)

U.S. Senator Jack Reed interviewed by Lee Pacchia, Bloomberg, September 20, 2012

"I think we need much more emphasis on what's going on. I think we have to look very carefully. We've had some wake up calls - the flash crash, the situation with the Facebook public offering - and so we've

been put on notice we have to look."

["SCHUMER TO SEC: IMPOSE TOUGHER RULES ON HIGH-FREQUENCY TRADERS TO CURB STOCK PRICE VOLATILITY AND PREVENT ANOTHER FLASH CRASH"](#)

U.S. Senator Charles E. Schumer, August 11, 2010

"This disappearance of high frequency traders and their withdrawal of liquidity reveal a serious problem with our market regulation."

See also ["SCHUMER TO SEC: SLOW DOWN HIGH-FREQUENCY TRADERS WHEN MARKETS GET VOLATILE; SENATOR ALSO CALLS FOR PROBE INTO 'QUOTE STUFFING,' POSSIBLE BAN ON SUB-PENNY BIDS"](#)

Prosecutors

["Cracking Down on Insider Trading 2.0"](#)

Eric T. Schneiderman, New York Attorney General, October 11, 2013

"Small groups of privileged traders have created unfair advantages for themselves by combining early glimpses of critical data with high-frequency trading – superfast computers that flip tens of thousands of shares in the blink of an eye. This new generation of market manipulators has devised schemes that allow them to suck all the value out of market-moving information before it hits the rest of the street."

["Remarks on High-Frequency Trading and Insider Trading 2.0"](#)

Eric T. Schneiderman, New York Attorney General, March 18, 2014

"It is up to those of us who regulate and who enforce the securities laws to deal with the fact that these traders are now benefiting from special, early access to information that can't be used the same way by the rest of the markets....One of the worst problems we've discovered as we've looked at this over the last year is the tendency for our markets and institutions to start catering to high-frequency traders, and becoming enablers of this particularly dangerous type of trading."

Other

["High-Frequency Trading: Background, Concerns, and Regulatory Developments"](#)

Congressional Research Service, June 19, 2014

"This report provides an overview of HFT in the equities and derivatives markets regulated by the SEC and the CFTC. It also examines the Flash Crash of 2010 and the role that HFT may have played, as well as recent regulatory developments."

["ESRB response to the ESMA Consultation Paper"](#)

European Systemic Risk Board, September 21, 2011

"There is also a growing concern that the expansion of HFT might undermine investor confidence and their willingness to participate in the markets."

["Position Paper"](#)

Securities and Markets Stakeholder Group, European Securities and Markets Authority (ESMA), October 26, 2011

"On one hand, studies demonstrate that HFT firms are also active during times of crises, but on the other hand, they also found that when volatility is rising, HFTs increase their demand for liquidity, while decreasing their supply of liquidity."

High Frequency Trading Defined

Definitions of "high frequency trading" (HFT) can vary, but every definition published to date includes one common attribute: High frequency trading includes any business model or trading strategy where positions in the market are bought and sold quickly, often hundreds or even thousands of times a day. High frequency traders rarely hold on to a position overnight, and usually close a position within minutes or even within seconds.

Industry Participants

"The main innovation that separates high-frequency from low-frequency trading is a high turnover of capital in rapid computer-driven responses to changing market conditions."

Irene Aldridge, *High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems* (2009).

"While traditional buy-side trading strategies hold positions for weeks or even months, HFT is characterized by fast turnover of capital. Instead of capturing large price changes over extended periods of time, HFT aims to book multiple small gains over short periods of time. An overwhelming 86% [of survey respondents] believe that the term 'high-frequency trading' referred strictly to holding periods of only one day or less."

Irene Aldridge, "FINalternatives Survey: High-Frequency Trading has a Bright Future," (2009).

"High frequency traders come from every kind of firm. Banks, investment funds, commodity trading advisors and proprietary trading firms all use computers to execute strategies that turn positions over frequently."

Richard Gorelick, in "Making Markets: A Conversation with Five High-frequency Trading Firms," *Futures Industry* magazine (January, 2010).

"High frequency trading is best understood as a subset of algorithmic trading that is characterized by high levels of messaging deployed in a very low latency infrastructure as well as high turnover with short holding periods."

CME Group letter, "Public Comment on Consultation Report: Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency," (2011).

"High-frequency trading is a method of trading that involves frequent turnover of positions, not a strategy in itself."

FIA Principal Traders Group / European Principal Traders Association, "FIA Principal Traders Group and FIA European Principal Traders Association Response to the IOSCO Consultation Report: Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency," (2011).

"High-frequency traders (a) require a high-speed trading infrastructure, (b) have investment time horizons less than one day, and (c) generally try to end the day with no positions whatsoever." (Emphasis in original.)

Rishi K. Narang, "Inside the Black Box: A Simple Guide to Quantitative and High Frequency Trading" (2013)

Academics

"HFTs are identified as those firms with extremely high volume, low intraday inventory and low overnight inventory....HFT firms stand out as a distinct cluster, with daily trading volume orders of magnitude higher than other traders."

Baron, Brogaard, Kirilenko, "Risk and Return in High Frequency Trading" (2014).

"HFT is a type of investment strategy whereby stocks are rapidly bought and sold by a computer algorithm and held for a very short period, usually seconds or milliseconds."

Jonathan Brogaard, "The Activity of High Frequency Traders" (2011).

"[HFT] is generally defined as the rapid and continuous buying and selling of a financial asset while taking only small intraday positions and ending the day with no inventory."

Jonathan Brogaard, "The ABCs of HFTs: a primer on high-frequency trading" (2014).

"HFT is the combination of low-latency connectivity, short holding periods and low inventory positions."

Jonathan Brogaard, Corey Garriott, and Anna Pomeranets, "High Frequency Trading Competition" (2014).

"High frequency traders submit and cancel a massive number of orders and execute a large number of trades, trade in and out of positions very quickly, and finish each trading day without a significant open position."
Cvitanic, Kirilenko, "High Frequency Traders and Asset Prices" (2010).

"Indeed, the typical high frequency market maker turns over his or her inventory 5 or more times a day, explaining how high frequency firms have come to have such a high share of trading volume. These market makers also seek to hold very small or even zero inventory positions at the end of the session. "
Easley, Lopez de Prado, O'Hara, "The Microstructure of the 'Flash Crash'", (2010).

"Like traditional intermediaries HFTs are central to the trading process, have short holding periods, and trade frequently."

Hendershott, Riordan, "High Frequency Trading and Price Discovery", (2011).

Regulators

"[H]F traders execute trades in matters of milliseconds on electronic order books and hold new equity positions possibly down to a 'sub-second.' HFT generally involves getting in and out of positions throughout the day with a 'flat' position at the end of the day."

Committee of European Securities Regulators, "Micro-structural issues of the European equity markets" (2010) .

"Trading activities that employ sophisticated, algorithmic technologies to interpret signals from the market and, in response, implement trading strategies that generally involve the high frequency generation of orders and a low latency transmission of these orders to the market. Related trading strategies mostly consist of either quasi market making or arbitraging within very short time horizons. They usually involve the execution of trades on own account (rather than for a client) and positions usually being closed out at the end of the day."

European Securities and Markets Authority, "Final Report: Guidelines on systems and controls in an automated trading environment for trading platforms, investment firms and competent authorities" (2011) .

"We generally characterise HFT as automatically generating large numbers of orders based on price movements and market information, holding positions for a very short time, and ending the day with a zero position."

Greg Medcraft, Chairman, Australian Securities and Investments Commission (2012).

"Other characteristics often attributed to proprietary firms engaged in HFT are...(3) very short time-frames for establishing and liquidating positions..."

Mary L. Schapiro, Chairman, U.S. Securities and Exchange Commission, testimony before the Subcommittee on Securities, Insurance, and Investment of the United States Senate Committee on Banking, Housing, and Urban Affairs, May 20, 2010.

"A number of common features and trading characteristics related to HFT can be identified...It is characterized by a high daily portfolio turnover and order to trade ratio (i.e. a large number of orders are cancelled in comparison to trades executed); It usually involves flat or near flat positions at the end of the trading day...Positions are often held for as little as seconds or even fractions of a second."

Technical Committee of the International Organization of Securities Commissions, "Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency: Final Report" (2011) .

"Other characteristics often attributed to proprietary firms engaged in HFT are...(3) very short timeframes for establishing and liquidating positions..."

U.S. Securities and Exchange Commission, "Concept Release of Equity Market Structure" (2010) .

"There is no widely accepted definition of HFT, but it typically exhibits some common characteristics, such as: (1) high volume of trades on a daily basis but low level of profits per trade; (2) extreme short stock holding period (I know of one HFT firm operated out of the west coast of the US that boasts its average holding period for US equities is 11

seconds); (3) submitting numerous orders; and (4) no significant open position overnight."

Martin Wheatley, CEO of the Securities and Futures Commission in Hong Kong, and former deputy chief executive of the London Stock Exchange, (2010).

"The attribute that most clearly characterises high-frequency trading and differentiates it from other trading is the percentage of turnover bought and then sold, or sold and then bought, within each trading day. High-frequency traders tend to close out a high proportion of trading intraday, so their overnight positions are relatively small. This metric distinguishes high-frequency trading from the more widespread execution algorithms which trade in only one direction during a day."

Australian Securities and Investments Commission, "Report 331: Dark liquidity and high-frequency trading" (2013).

"HFT typically refers to the use of computerized trading to move in and out of positions rapidly, generally ending the day flat with little or no exposure to the market on an overnight basis."

U.S. Treasury, Financial Stability Oversight Council, "Financial Stability Oversight Council: 2012 Annual Report" (2012).

"High-frequency trading: A highly automated form of algorithmic trading that is often characterised by holding positions very briefly in order to take advantage of short-term price rises and falls."

HM Treasury, Bank of England, Financial Conduct Authority, "Fair and Effective Markets Review" (2015).