The Brattle Group

ISSUE 02 | 2011

Finance

Current Topics in Corporate Finance and Litigation

Trading at the Speed of Light:

The Impact of High-Frequency Trading on Market Performance, Regulatory Oversight, and Securities Litigation

By Pavitra Kumar, Michael Goldstein, Frank Graves, and Lynda Borucki

About this Newsletter

In this issue of Finance we discuss the evolution of high-frequency trading over the last decade, its impact on market efficiency and liquidity, and potential regulatory and legal implications.

Contents

For more information about the authors or *The Brattle Group*, please visit **www.brattle.com.**

Introduction

High-frequency trading (HFT) describes the execution of electronic trading strategies involving extremely rapid capital turnover. It is characterized by the use of computer algorithms to analyze quote data and detect and exploit trading opportunities, with windows as short as milliseconds or even microseconds. High-frequency traders compete on a basis of speed for an abundance of very small but fairly consistent margins. While no institution explicitly tracks the performance of high-frequency funds, anecdotal evidence suggests that high-frequency trading firms generated mostly positive returns during the recent credit crisis, reinforcing the growing popularity and volume of HFT activity.[1] The vast majority of volumes now traded on the New York Stock Exchange (NYSE) and other U.S. exchanges are HFT transactions.

In this newsletter we describe the evolution of high-frequency trading over the past decade and some of the key features of HFT strategies. We also evaluate the impacts that high-frequency trading has had on the markets, investigating issues such as the fairness of HFT practices, whether HFT improves market efficiency, how it affects market liquidity, and whether it has potentially adverse side effects such as increasing price volatility. Finally, we examine the regulatory and legal implications of the current prevalence of HFT, and summarize the proposed solutions to the concerns that high-frequency trading has recently created in the markets.

The Evolution of High-Frequency Trading

Electronic Market Timeline

1980s – First electronic trading systems appeared.

1992 – The Chicago Mercantile Exchange (CME) launched its first electronic platform, Globex.

1993 – Systematic/electronic trading was enabled for CME equity futures.

2000 – New York-based International Securities Exchange (ISE), the first fully electronic U.S. options exchange, was launched.

2003 – NYSE introduced automated quote dissemination.

2010 – All seven U.S. exchanges offered either fully electronic or a hybrid mix of floor and electronic trading in options.

High-frequency trading began to take flight after the U.S. Securities and Exchange Commission (SEC) introduced regulation for alternative trading systems, including electronic exchanges, in 1998.[2] At the beginning of the decade, HFT represented less than 10 percent of all equity trades in the U.S., whereas today HFT firms account for over 70 percent of all U.S. equity exchange trading volume.[3] Furthermore, high-frequency trades had an average round-trip order execution time ("latency") of several seconds in the early 2000s, whereas by 2010, latency had decreased to milli- and even microseconds.[4] HFT is also rapidly growing in popularity in Europe and Asia, accounting for approximately 30 to 40 percent of equities and futures trading volume in the former, and 5 to 10 percent of equity volume in the latter.[5] The TABB Group, a financial consultancy, estimated that HFT comprised 56 percent by value of all equity trades in the U.S. and 38 percent in Europe in 2010.[6]

The success of high-frequency trading has primarily stemmed from the electronic models' capability to simultaneously read, process, and capitalize on trading opportunities derived from large volumes of intra-day data much more quickly than human traders. By facilitating very fast and inexpensive trading, computerized markets have allowed dealers to offer liquidity via electronic proprietary trading systems, either acting as market-makers who commit capital to connect buyers to sellers, or as arbitrageurs who connect buyers in one market to sellers in another correlated market.[7] Although the increasing volume of high-frequency trades has been reported in the media, HFT has caught the attention of the general public due in large part to a few extreme and dramatic price drops or spikes that have occurred over the past year. These events have raised questions about the risks of HFT and whether regulatory oversight is necessary.

High-Frequency Trading Strategies and Practices

High-frequency trading firms take short-term positions in a variety of financial instruments including equities, options, futures, exchange-traded funds (ETFs)[8], and currencies. As well as being characterized by brief position-holding periods, HFT strategies usually have very low latency. HFT strategies are typically backed by proprietary capital, with the major participants being broker-dealer proprietary trading desks, hedge funds (such as Renaissance Technologies, WorldQuant, D.E. Shaw, and Millennium), and proprietary trading groups.

Many HFT firms are based in New York, London, Singapore, and Chicago, and utilize strategies that capitalize on their geographic location. For instance, several Chicago-based proprietary trading firms (e.g., Getco LLC) exploit their proximity to the Chicago Mercantile Exchange to develop faster trading strategies for futures, options, and commodities, while New York-based firms (e.g., Hudson River Trading LLC) tend to have a preference for U.S. equities. European time zones give London-based firms an advantage in trading currencies, and Singapore-based firms specialize in Asian markets.[9]

There is no formal regulatory or legal bright-line definition for what constitutes HFT; rather, it is distinguished from other algorithmic trading as a matter of degree and trading conventions. For example, HFT firms usually liquidate their entire portfolios on a daily basis rather than carrying positions overnight.[10] The reason for this practice is that given the current volatility in the markets and the extension of global trading activity to 24-hour cycles (for instance, in the electronic foreign exchange markets), overnight positions involve high levels of risk.[11] Moreover, overnight positions taken out on margin have to be paid for at an interest rate referred to as an overnight carry rate (usually slightly above LIBOR rates), decreasing their profitability.[12]

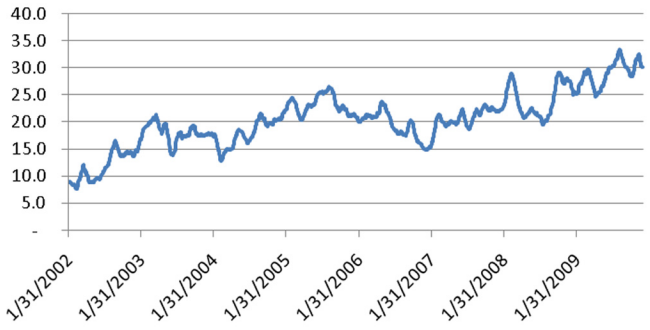
As a result of unwinding all their positions before the end of each trading day, HFT firms do not tend to take large positions, place substantial amounts of capital at risk, or require or use high levels of leverage. In fact, the average estimated net profit margin for high-frequency traders in the U.S. equity market is only around 0.1 cents per share traded, thus necessitating very rapid turnover.[13]

One important consequence of these practices is that the direct impact of HFT strategies on longer term market prices facing conventional investors is difficult to determine. In this regard, HFT activities can be distinguished from the more general category of algorithmic trading, where the latter encompasses a wider range of computerized trading strategies, some of which involve much longer position-holding periods (including overnight positions) and consequently may have a more significant effect on long-term prices.

In most HFT strategies, quotes only last for a few micro- or milliseconds at a maximum, and therefore are not actionable by the majority of market participants. There is also evidence that some HFT systems deliberately cancel many of their orders almost immediately after placing them, as they do not intend for the trades to carry through. The false orders are used instead as part of a "pinging" tactic to discover the price other traders are willing to pay.[14] These practices, known as "flickering quotes" or "quote stuffing," have been claimed to generate an overload of data to market centers, potentially increasing systemic risk.

In its February 18, 2011 report, the Joint CFTC-SEC Advisory Committee noted the recent trend of high cancellation rates and their associated costs. To reduce and redistribute such costs, the Advisory Committee has recommended that the SEC and the U.S. Commodity Futures Trading Commission (CFTC) consider a "… uniform fee across all Exchange markets that is assessed based on the average of order cancellations to actual transactions effected by a market participant."[15] Evidence of this trend is presented in Figure 1.

Figure 1 - Cancellation/Execution Ratio



Source: *NASDAQ ITCH data provided by Knight Capital Group, from Angel, Harris, and Spatt, "Equity Trading in the 21st Century," USC Marshall School of Business, Marshall Research Paper Series, Working Paper FBE 09-10, May 18, 2010. ITCH is a direct data-feed interface that allows customers of the NASDAQ to observe or disseminate information about stock trading activities.*

This graph presents the ratio of order cancellations per execution from National Association of Securities Dealers Automated Quotations (NASDAQ) ITCH data. Note that the ratio of orders cancelled to orders executed is far greater than one to one, and has more than tripled in recent years — from under 10 at the beginning of 2002 to over 30 by the end of 2009.

Trading Strategies

Most algorithmic strategies using HFT fall within one or more of the following four categories:[16]

Automated Liquidity Provision

This strategy, also known as market-making, involves buying and selling securities to provide two-sided markets on exchanges. Specifically, high-frequency market-makers place bid (buy) and offer (sell) limit orders, and derive profits from the resulting bid-offer spreads. Holding periods for these strategies tend to be less than one minute, if not shorter.

On all exchanges and electronic communication networks (ECNs), stock market-makers also now receive liquidity rebates of up to 0.25 to 0.30 cents a share for each share that is sold to, or purchased from, each posted bid or offer.[17] As the exchanges and ECNs make money from "tape revenue,"[18] these rebates are designed to provide additional compensation to market-makers, beyond the bid-ask spread, for attracting order flow to the market centers.

This practice has led to the development of rebate trading strategies.[19] Exchanges and ECNs cover rebate traders' commission costs and exchange fees because they are considered to be adding liquidity. This makes it worthwhile for rebate traders to buy and sell shares at the same price, in order to generate their liquidity rebate on each trade.[20]

Market Microstructure Trading

Under this category of strategies, also known as "trading the tape," HFT machines analyze the flow of observed quotes in order to extract price information and reverse-engineer trading party order flow — in essence, to predict likely future volumes of buy and sell orders, and thereby anticipate price momentum trends. Holding periods for these strategies tend to last up to 10 minutes. One type of strategy within this class, known as "filter trading," involves monitoring large amounts of stocks for abnormal price changes or volume activity, precipitated, for example, by events such as corporate news announcements.[21]

Event Arbitrage

Certain ad hoc events, such as company announcements of earnings or other economic figures, generate abnormal returns amongst affected securities. High-frequency traders capture such opportunities to generate short-term profits, with position-holding periods lasting from 30 minutes to one hour.

Statistical Trading

These rapid trading strategies exploit temporary and potentially fleeting discrepancies from statistical relationships amongst liquid securities across different markets, including equities, futures, and foreign exchanges. Statistical arbitrage opportunities arise due to the fact that long-term investors create a price impact in the securities they accumulate or sell. Because these securities are correlated with other securities, the price impact is propagated across markets.

Strategies in this category typically function by specifying a maximum range of variance of price differentials between a given set of securities, and taking a counter trade when that range is exceeded.[22] High speed trading is used to exploit, for example, covered interest rate parity discrepancies in the foreign exchange market, price discrepancies between highly correlated stocks, and also between derivatives and their underlying assets. Position-holding periods for these strategies can last as long as a day.

The Speed of High-Frequency Trading

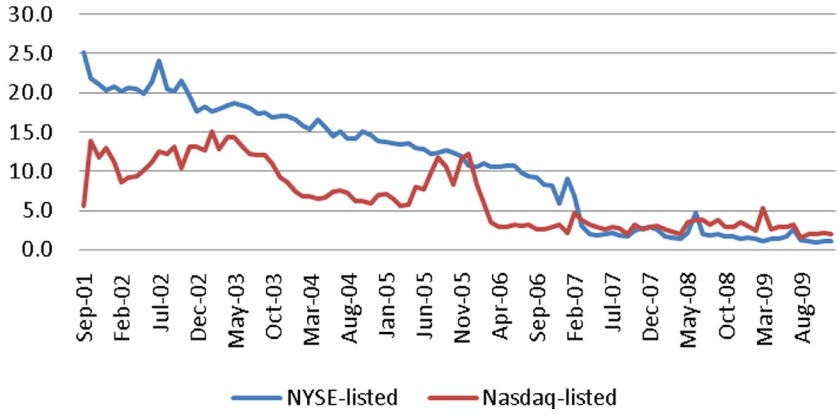
As a result of the proliferation of HFT, exchanges are now competing with each other to support faster trade execution times, or lower latencies. For instance, in June 2007, the London Stock Exchange began a new system called TradElect, which promised to deliver an average 10 millisecond turnaround time (or latency) from placing an order to final confirmation, and could process 3,000 orders per second.[23] Today, however, latencies as low as one millisecond or less are available in several U.S. exchanges and over-the-counter (OTC) markets. For example, it takes 16 microseconds for a share trade to be completed using a system built by Algo Technologies, a U.S.-based trading system technology company.[24]

The implication of this significant decline in latencies is that trading is now so fast that HFT brokers in a given financial center, such as Chicago, cannot know what the most recent quote was in a geographically separate financial center, such as New York. This is because light travels at "only" 186 miles per millisecond, while the straight-line distance between New York and Chicago is 711 miles. Therefore, in 16 microseconds (the latency of trades implemented by Algo Technologies), light can only travel three miles (about the distance from Wall Street to midtown Manhattan), whereas it would take 3.82 milliseconds to travel from New York to Chicago. Assuming one trade occurs per 16 microseconds, by the time a broker in Chicago learns about a trade in New York (if this information travels at the speed of light), 239 trades would have already occurred without the broker's knowledge. Evidence of the dramatic decrease in trade execution times over the last decade is displayed in Figure 2.

Co-Location by HFT Firms

In order to realize greater benefits from implementing low-latency strategies, high-frequency trading firms often engage in the practice of "co-location." This means that HFT firms move their servers that execute their trading strategies into co-located facilities, i.e., to data centers that are located as close as possible to exchanges' and their electronic communication networks' "matching engines."[25]

Figure 2 - The Speed of Executing Market Orders



Source: *Rule 605 data from Thomson for all eligible market orders (100-9999 shares), from Angel, Harris, and Spatt, "Equity Trading in the 21st Century," USC Marshall School of Business, Marshall Research Paper Series, Working Paper FBE 09-10, May 18, 2010.*

This graph depicts the strong and steady decline in the execution time (in seconds) for small market orders, both for NYSE-listed and NASDAQ-listed stocks, over the past decade.

One recent example of a co-location project has been the creation of a 428,000-square-foot data center in Chicago. This new center houses the Chicago Mercantile Exchange's Globex electronic futures and options trading platform, as well as space for traders to install their computers next to the exchange's machines at a cost of approximately $25,000 a month per rack of computers.[26]

Given the currently fragmented nature of the markets, however, with HFT firms sometimes utilizing several trading venues simultaneously, it is not enough to just co-locate next to the primary exchange on which they provide liquidity. Rather, these trading firms require connections to their other trading venues as well. This kind of fragmentation can cause the de-linking of certain markets, such as the New York equity market and the Chicago futures markets.

One solution to this issue is for HFT firms to co-locate with one main exchange and then use a low-latency shared infrastructure to reach their other trading venues.[27] An example of such an innovation is the recent construction of an 825-mile direct route between the New York and Chicago financial markets by the startup, Spread Networks, connecting New York and Chicago in fewer than 15.75 milliseconds (the lowest latency of any commercially available wavelength service connecting America's largest financial centers).

Recent research efforts have also focused on techniques to minimize delays in data transmission when HFT firms trade securities in different locations around the world. For instance, two scientists affiliated with the Massachusetts Institute of Technology have examined pairs of the 52 largest global exchanges in order to calculate the optimal locations where trading between the financial centers should be centered at any point in time.[28]

Since HFT strategies exploit price discrepancies between securities traded on separately located exchanges, the optimally located server should receive information from those exchanges almost simultaneously. If the prices of a pair of exchanges move at the same speed, the best location should be the midpoint between them, but if prices move more rapidly on one exchange than another, the optimal location should be positioned closer to the faster exchange.

Optimizing over location and transaction speed, the authors found a number of sites — including remote spots in central Africa, Canada, Siberia, and even in the middle of the Indian Ocean — that are the most advantageously located places between pairs of major financial centers. In the short term, this technique could also be used to find optimal trading locations within a single city with multiple data centers, such as New York.[29]

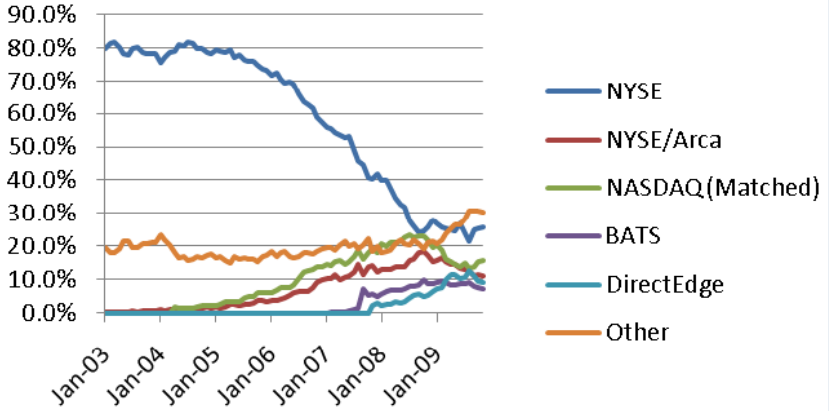
The Market Consequences of High-Frequency Trading

Around 20 HFT firms currently dominate trading volumes in the U.S. equity cash and futures markets. As a result of the increased volume of HFT over the last decade, more fully automated markets such as NASDAQ, Direct Edge, and BATS (Better Alternative Trading System) have managed to seize market share from less automated markets such as the NYSE (see graph in the sidebar below).

It is not immediately obvious that an increased volume of algorithmic trading in general should lead to an increase in market liquidity, given that it could generate more activity in both liquidity supply and demand, and a dominance of the latter could actually decrease liquidity and result in wider spreads. Several financial industry sources claim, however, that high-frequency traders have helped generate greater liquidity in the markets, both by acting as market-makers and, as statistical arbitrageurs, by ensuring that information is propagated from securities traded by long-term investors to other correlated securities. There is evidence from academic literature that algorithmic trading improves liquidity for large-cap stocks in particular, reducing adverse selection costs, narrowing spreads, and increasing the informativeness of quotes.[30]

The Impacts of Electronic Trading on Market Shares of Traditional Listed Exchanges

From 2005 onwards, the NYSE market share of volume in its own listed stocks has been steadily and dramatically decreasing, from around 80 percent in 2005 to 25 percent by the end of 2009. Today, the vast majority of NYSE stock trades do not transpire on the NYSE itself. This trend coincides with the adoption of new rules under the SEC Regulation National Market System (NMS),[A] whose implementation as part of the "Order Protection Rule" was phased into the markets starting in mid-2006. This rule resulted in investors being able to receive the best price available among quotations that were displayed electronically by an automated trading center, and that were immediately available for execution. As a result, liquidity was now allowed to go to the best automated quote, enabling electronic trading platforms or ECNs to compete with traditional floor-based trading systems such as the NYSE.



Source: *Barclays Capital Equity Research, from Angel, Harris, and Spatt, "Equity Trading in the 21st Century," USC Marshall School of Business, Marshall Research Paper Series, Working Paper FBE 09-10, May 18, 2010.*

The chart shows that NASDAQ matched share volume increased from 2005 to 2009, but this too later fell as volume traded through new automated entrants such as BATS and Direct Edge increased. The "Other" segment, which includes dark pool[B] trading systems, has increased its market share over the last two years as well.

Another consequence of the increasing automation of markets is that there has been a wave of consolidation amongst the traditional exchanges. For example, on February 10, 2011, NYSE Euronext and Deutsche Börse AG confirmed that they were in advanced merger talks, potentially creating the world's largest financial exchange. The main motivation for this transaction can be traced to the rise of dark pools and other alternative trading platforms as competitors for market share, forcing exchanges to seek other sources of revenue.

[A] Regulation NMS (adopted by the U.S. SEC in 2005) contains four related proposals designed to modernize the regulatory structure of the U.S. equity markets: (1) order protection, (2) intermarket access, (3) sub-penny pricing, and (4) market data. See http://www.sec.gov/rules/final/34-51808.pdf for the final rule.

[B] Dark pools are private electronic transaction networks, typically maintained by major banks, brokers, and securities companies, where stocks are bought and sold by clients of those companies. The bid, offer, and sale prices for dark pool orders are not published to exchanges such as the NYSE and trader identities remain anonymous.

One issue that has arisen when investigating the market impacts of algorithmic trading is that it cannot be directly observed whether a particular order is generated by an HFT algorithm at any time (given that most trades do not rely on human intermediaries, but instead send orders to trading venues electronically). Therefore, proxies for algorithmic trading and the HFT portion thereof have to be used instead, such as the rate of electronic message traffic normalized by trading volume.[31] This creates some analytic uncertainty surrounding the effects of HFT.

The combined efficiencies from high-frequency proprietary trading and from the operation of low-cost ECNs have substantially decreased the costs of trading for both NASDAQ and traditional floor-based exchange-listed stocks.[32] At the same time, however, the increase in speed and volume of trading due to HFT has also meant that the need for higher bandwidth has added significantly to brokers' costs. For example, the costs of increasing data capacity and updating quote streaming infrastructure have recently been cited as growing between "seven and nine percent per month"[33] for online brokers and were also cited as a concern by the Joint CFTC-SEC Advisory Committee in February 2011.[34]

In terms of how HFT impacts market performance overall, arguments have been proposed on both sides. On one hand, because high-frequency traders regularly capitalize on the most minute of market inefficiencies, HFT firms have claimed that they improve market efficiency, and therefore help to reduce volatility. On the other hand, some have suggested that the ability of HFT firms to leave the market rapidly has made the markets "fragile."[35]

In particular, the Joint CFTC-SEC Advisory Committee recently noted that "[i]n the present environment, where high-frequency and algorithmic trading predominate … 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."[36]

Furthermore, HFT firms do not usually carry open positions after the close of trading. This means that these traders will often rapidly sell large positions at the very last minute in order to balance their books at the end of the trading day, potentially causing a significant movement in prices. In its testimony in October 2009 before the Senate Banking Subcommittee, the SEC also stated that swifter access to the markets could enable high-frequency traders to successfully implement "momentum" strategies designed to trade on sharp price movements, thus contributing further to short-term volatility.[37]

To date, however, there has been no concrete evidence of HFT firms increasing volatility. The main impetus for these concerns may be a few "rogue" events that have captured public attention, especially over the past year. These may not be a manifestation of what HFT causes when it is working as planned, but rather what might happen if a flawed algorithm goes too far.

One of the most dramatic examples of such a market-wide event is the sudden plunge in the Dow Jones Industrial Average on May 6, 2010 (the "Flash Crash"). This is described in the sidebar on page 8. There have also been numerous, less broad-impact incidents of sudden stock price movements recently, in both directions, that some have speculated were directly connected to HFT. Some of these occurrences in the U.S. markets are:

- *Diebold Inc.: ↓ 30% in six seconds (6/2/2010 on electronic venues such as NASDAQ and BATS exchanges)*
- *Washington Post Co.: ↑ 99% in less than one second (6/16/2010 on NYSE Arca)*
- *Progress Energy Inc.: ↓ 90% in less than one second (9/27/2010 on NASDAQ)*
- *Aaron's Inc.: ↑ 12% in less than one second (10/26/2010 on various exchanges)*
- *Apple: ↓ 1.7% in four minutes (2/10/2011 on NASDAQ)*

Movement in the stocks of the Washington Post Co., Progress Energy Inc., and Aaron's Inc. triggered the SEC circuit breakers created after the Flash Crash of May 2010. Upon initial implementation by the SEC in June 2010, this single-stock circuit breaker system was applied to S&P 500 stocks only. It was subsequently expanded in September 2010 to include Russell 1000 stocks and certain actively traded ETFs. As of the beginning of February 2011, 19 companies in total have had their trading halted by the SEC circuit breakers, according to data compiled by Bloomberg.

There have been similar instances of abrupt price plunges internationally as well. For example, on June 1, 2010, Japan's Nikkei 225 Stock Average Futures contracts plummeted by 1.1 percent seconds after the market opening, due to an erroneous, massive algorithm-based sell order placed by Deutsche Bank on the Osaka Securities Exchange.

The Flash Crash of May 6, 2010

The May 6, 2010 "Flash Crash" is widely cited as an effect of HFT, although this has not been officially proven. On this date, the Dow Jones Industrial Average fell by nearly 1,000 points in less than 30 minutes before rebounding almost as quickly. This was the Dow Jones' largest intra-day point loss in history. On October 1, 2010, the SEC and CFTC issued a report examining the causes of the Flash Crash.

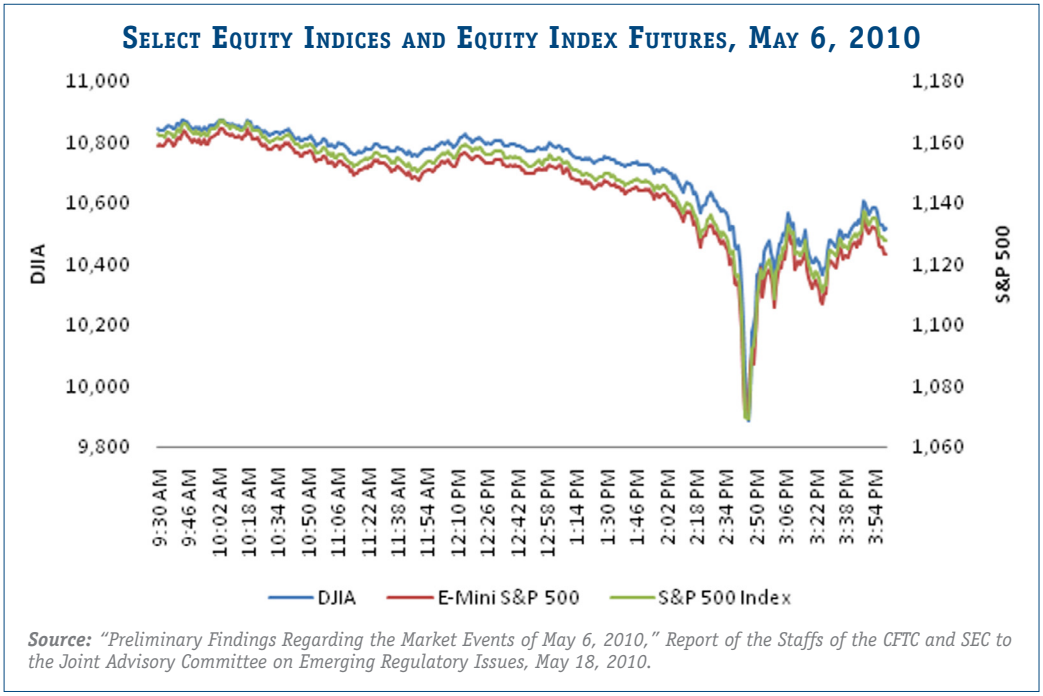
The SEC report explains that the stock market's sudden decline on that day was actually caused by the rapidly executed sell order of a $4.1 billion block of E-Mini Standard & Poor's 500 futures contracts on the Chicago Mercantile Exchange. The order was originated by a large fundamental trader holding long-term positions (a mutual fund group, reportedly Waddell & Reed), and not by an HFT firm. The trade occurred at a time when the markets were already facing increased volatility due to fear of Greek debt downgrades and further economic turmoil in Europe. This sale was reportedly conducted through an automated execution algorithm provided by Barclays Capital, taking account only volume, not time or price, so that the $4.1 billion worth of sell orders were unloaded into the futures market in just over 20 minutes.

According to a paper on the Flash Crash by Kirilenko, Kyle, Samadi, and Tuzun,* high-frequency traders were among the buyers of the first batch of these sell orders, but then sold the contracts aggressively to reduce their inventories during the next few minutes, exacerbating the price decline. The total trading volume generated by HFT firms also increased dramatically around the time of the crash, given that as volatility increased, long-term traders withdrew from the market, and thus high-frequency traders had to buy and sell contracts from one another, generating a "hot-potato" effect. After a five second trading pause was automatically activated in the E-Mini, however, long-term traders re-entered the market and rapidly accumulated long positions in the contracts, leading to a swift recovery in prices.

Therefore, even if the May 2010 Flash Crash was not primarily caused by HFT firms, there is evidence to suggest that they did augment market volatility through their responses to the intense selling pressure on that day.

---

* Kirilenko, Kyle, Samadi, and Tuzun, "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market," Working Paper, January 12, 2011.



Source: *"Preliminary Findings Regarding the Market Events of May 6, 2010," Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues, May 18, 2010.*

The Fairness of High-Frequency Trading

Several tools and technologies used by HFT firms are available to other investors, while some are not, creating market advantages for high-frequency traders that have been termed by some as unfair. For example, co-location, the ability to access direct data feeds from exchanges, and sophisticated order execution algorithms are services that can be purchased by any investor. However, the cost-benefit tradeoff for investing in these tools and capabilities is likely to be much more favorable to organized, institutional high-frequency traders, given that the proportional increase in HFT profits from minute improvements in trading speed is potentially far greater than for long-term investors.

On the other hand, the ability of HFT firms to use orders known as Intermarket Sweep Orders (ISO orders)[38] is generally unavailable to investors who are not broker-dealers. The ability to use ISOs has potentially significant consequences, given that under the ISO exception to the Regulation NMS Order Protection Rule (which requires traders to transact on a trading venue at the lowest price rather than on a venue offering the quickest execution), a trading center may execute immediately any order identified as an ISO order without regard for better-priced protected quotations displayed at other trading centers. Therefore, this asymmetric access to ISO orders places buy-side investors at a substantial disadvantage to HFT firms, by enabling the latter to circumvent the Order Protection Rule and thus potentially jump ahead of their orders.[39]

Furthermore, many buy-side investors do not receive the maximum liquidity rebates from exchanges and ECNs (utilized by HFT firms in their automated liquidity provision strategies), given that market centers typically tier their rebates based on trade volume. This places high-volume, high-frequency traders at an advantage in capturing the highest rebates.

Regulatory and Legal Implications

The SEC is currently investigating HFT after lawmakers, including Senators Charles Schumer of New York and Ted Kaufman of Delaware, have questioned whether the practice is benefiting Wall Street at the expense of individual investors. Following the SEC and CFTC findings in their joint report on the Flash Crash that equity "market makers and other liquidity providers widened their quote spreads, others reduced offered liquidity, and a significant number withdrew completely from the markets,"[40] one major area of focus is whether high-frequency market-makers should be subject to regulations that would require them to stay active in volatile markets.

Other issues that the SEC and CFTC are addressing going forward include how to manage more effectively the current high-volume, high-volatility trading conditions generated by HFT; the restriction of co-location and mitigation of direct market access of unregulated and unsupervised entities; the creation of incentives to encourage more transparent liquidity; and the improvement of information provision by exchanges. The Joint CFTC-SEC Advisory Committee has proposed a number of specific recommendations in its February 2011 report, including:[41]

- *Expanding the current market-wide, single-stock circuit breaker rule implemented by the SEC to cover all but the most inactively traded listed equity securities, ETFs, options, and single-stock futures on those securities*
- *Imposing market-wide "limit up/limit down" features on trading (similar to those used in the futures markets) so that stocks that experience rapid declines can continue trading within a narrow band of prices*
- *Requiring futures exchanges to impose an additional tier of pre-trade risk safeguards, or circuit breakers with longer timeframes, as protection against extreme volatility*
- *Supporting the SEC's rules to ban broker-dealers from providing their customers "naked" or unfiltered access to the markets (i.e., access without any pre-trade checks or compliance screening), and recommending further testing of risk controls and supervisory procedures employed by broker-dealers that sponsor market access for their customers*
- *Requiring broker-dealers executing "internalized" or "preferenced" order flow (i.e., executing order flow via dark trading venues not visible to the public), to be subject to market-maker obligations to execute some material portion of their order flow during volatile market periods*

- *Providing incentives (i.e., preferential co-location provisions) or regulations to encourage market-makers to provide buy and sell quotes that are "reasonably related to the market"*
- *Implementing a system to fairly allocate the costs imposed by high levels of order cancellations*
- *Imposing reporting requirements for measures of liquidity and market imbalance for large market venues, and implementing a consolidated audit trail for the U.S. equity markets*

In addition to these regulatory oversight and allowable practices issues, there is a possibility that HFT activity will affect how liability and damages are proven or quantified in securities litigation. It does not appear that there have been any suits filed yet over the sharp market drops that may have been induced or aggravated by HFT. However, it is possible that this will occur in the future if there are more dramatic or widespread shocks. Below are a few speculations about what types of issues could arise. These are not offered as the most likely, or the most important ones that may occur. Rather, they simply illustrate how HFT may alter the landscape for finding and assessing harm.

Market Efficiency

There is an important presumption of market efficiency in price setting for many class action claims, as this assumption serves as the basis for reliance via fraud on the market. The financial economic notion of market efficiency is that security prices rapidly and accurately reflect available public information about the business prospects for the associated firm. However, if stock prices are becoming more significantly affected by momentum trading, which generally ignores economic fundamentals, it may be more difficult to attribute a stock price change to corrective disclosures, for example. Furthermore, the very existence of such rapid price reversals in individual securities, such as the sudden changes for Progress Energy or Washington Post Co. noted previously, could potentially lead a court to reject that the stock trades in an "efficient" market in the first place.

Best-Execution Obligations

Since 2006, U.S. broker-dealers have had a codified obligation to use "reasonable diligence" to place trades in the "best market" at the "best possible price" under prevailing market conditions. When trades and quotes are changing every millisecond, however, there may be exposure to disputes over what the best price is or how a trade was executed, or even what the "prevailing market conditions" are and therefore the brokers' obligations under them.

Wash Trades or "Simultaneous Sales"

It is illegal to create artificial volume of apparent trading by quickly buying and selling the same security through different dealers or exchanges. However, if only a short time interval applies to HFT, then defining simultaneity becomes strongly entangled with the purpose of the trades.

CONCLUSION

High-frequency trading is clearly here to stay, given that it has been riding a wave of technological momentum and innovation over the past decade. However, HFT has recently been generating a great deal of controversy, some of which may be an over-reaction. In principle, high-frequency trading should not have a large impact on prices, given that HFT firms control very little capital and take minute, very brief positions in securities. Moreover, high-frequency traders can provide greater liquidity and market efficiency, either by acting as market-makers or as statistical arbitrageurs across markets.

On the other hand, errant or poorly designed HFT programs without necessary risk controls could lead to occasional shocks or disruptive events, such as those we have witnessed globally over the past year. In addition, the implementation of certain HFT strategies has raised concerns about their fairness, given the availability of certain tools to high-frequency traders that are not widely available to other types of investors.

As a result of the controversies surrounding HFT and other less transparent corners of the markets, the CFTC and SEC are conducting ongoing investigations of the impacts of these strategies, and proposing solutions to address their potentially adverse side-effects. Finally, the increased volume of HFT over the past decade creates several possible ramifications for securities litigation in the future, to the extent that it changes our understanding of market efficiency and other metrics that affect liability and damages estimation in lawsuits.

ENDNOTES

[1] Aldridge, "How Profitable Are High-Frequency Strategies?" *Huffington Post*, July 26, 2010.

[2] The U.S. SEC adopted Regulation ATS (alternative trading system) in 1998. This regulation permitted electronic communication networks (ECNs, or alternative electronic trading systems that collect and match brokerage client orders automatically, outside of stock exchanges) the option of registering as stock exchanges or else being regulated under a separate set of standards.

[3] Iati, "The Real Story of Trading Software Espionage," *Advanced Trading*, July 10, 2009.

[4] Haldane, "Patience and Finance," Bank of England, September 2, 2010.

[5] *Ibid*.

[6] Grant, "High-frequency trading: Up against a bandsaw," *Financial Times*, September 2, 2009.

[7] Angel, Harris, and Spatt, "Equity Trading in the 21st Century," USC Marshall School of Business, *Marshall Research Paper Series*, Working Paper FBE 09-10, May 18, 2010.

[8] An exchange-traded fund is an investment fund traded on stock exchanges, which usually tracks an index, a commodity, or a basket of assets like an index fund.

[9] Aldridge, *High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems*, Wiley, 2009.

[10] *Ibid*.

[11] *Ibid*.

[12] "High-Frequency Trading (HFT)," *wikinvest.com* (accessed December 6, 2010).

[13] "Trade Worx / SEC letters," April 21, 2010. Available at: http://sec.gov/comments/s7-02-10/s70210-129.pdf.

[14] Arnuk and Saluzzi, "Toxic Equity Trading Order Flow on Wall Street," *Themis Trading LLC White Paper,* December 17, 2008.

[15] U.S. SEC, "Recommendations Regarding Regulatory Responses to the Market Events of May 6, 2010: Summary Report of the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues," February 18, 2011. Available at: http://www.sec.gov/spotlight/sec-cftcjointcommittee/021811-report.pdf.

[16] Aldridge, *High-Frequency Trading*.

[17] The NYSE offers rebates of up to $0.0022 (See: http://www.nyse.com/pdfs/nyse_equities_pricelist.pdf); NYSE Arca offers rebates of $0.0030 (See: http://www.nyse.com/pdfs/nysearcaMarketplaceFees112011-Clean.pdf); and NASDAQ offers rebates as high as $0.00295 (See: http://www.nasdaqtrader.com/content/ProductsServices/PriceList/pricesheet.pdf).

[18] Tape revenue is generated by exchanges and ECNs from the sale of data to third-party vendors, such as Bloomberg for professional investors and Yahoo for retail investors. See Arnuk and Saluzzi, "Toxic Equity Trading."

[19] "The World Of High Frequency Trading: 6 Primary Strategies," *www.T3Live.com* (accessed September 15, 2010).

[20] Arnuk and Saluzzi, "Toxic Equity Trading."

[21] "The World Of High Frequency Trading: 6 Primary Strategies," *www.T3Live.com*.

[22] *Ibid*.

[23] MacDonald, "LSE leads race for quicker trades," *The Wall Street Journal Europe*, June 19, 2007.

[24] Grant, "Light speed ahead: how technology is changing trading," *Financial Times*, September 24, 2010.

[25] Schmerken, "High-Frequency Trading Shops Play the Colocation Game," *Advanced Trading*, October 5, 2009.

[26] Bowley, "The New Speed of Money, Reshaping Markets," *The New York Times*, January 1, 2011.

[27] Schmerken, "High-Frequency Trading."

[28] Wissner-Gross and Freer, "Relativistic statistical arbitrage," *Physical Review E*, Vol 82, 2010.

[29] Zax, "Why High-Speed Traders Should Set Up Shop in Siberia," *Fast Company*, November 5, 2010.

[30] Hendershott, Jones, and Menkveld, "Does Algorithmic Trading Improve Liquidity?" *The Journal of Finance*, February 2011.

[31] *Ibid*.

[32] Angel et al, "Equity Trading in the 21st Century."

[33] Kulikowski, "Quote-Stuffing Hits Brokers' Bottom Line," *TheStreet.com,* September 24, 2010.

[34] U.S. SEC, "Summary Report of the Joint CFTC-SEC Advisory Committee."

[35] Bowley, "'Flash Crash' Panel Lays out Several Steps to Diminish Volatility in the Market," *The New York Times*, February 18, 2011.

[36] U.S. SEC, "Summary Report of the Joint CFTC-SEC Advisory Committee."

[37] Brigagliano, "Testimony Concerning Dark Pools, Flash Orders, High Frequency Trading, and Other Market Structure Issues," Before the Senate Banking Subcommittee on Securities, Insurance, and Investment, October 28, 2009. Brigagliano is the Co-Acting Director of the Division of Trading and Markets at the U.S. Securities and Exchange Commission.

[38] An Intermarket Sweep Order (ISO) is defined as a limit order that: (1) is identified as an ISO order when routed to a trading center, and (2) simultaneously with the routing of the limit order, one or more additional limit orders (also identified as ISO orders) are routed to execute against all better-priced protected quotations displayed by other trading centers up to their displayed size.

[39] "Trade Worx / SEC letters."

[40] U.S. SEC and the CFTC, "Findings Regarding the Market Events of May 6, 2010," September 30, 2010. Available at: http://www.sec.gov/news/studies/2010/marketevents-report.pdf.

[41] U.S. SEC, "Summary Report of the Joint CFTC-SEC Advisory Committee."

The Brattle Group

Functional Practice Areas

- Antitrust/Competition
- Commercial Damages
- Environmental Litigation and Regulation
- Forensic Economics
- Intellectual Property
- International Arbitration
- International Trade
- Product Liability
- Regulatory Finance and Accounting
- Risk Management
- Securities
- Tax
- Utility Regulatory Policy and Ratemaking
- Valuation

Industry Practice Areas

- Electric Power
- Financial Institutions
- Natural Gas
- Petroleum
- Pharmaceuticals, Medical Devices, and Biotechnology
- Telecommunications and Media
- Transportation

About the Authors

Dr. Pavitra Kumar, an associate at *Brattle*, specializes in empirical finance, asset pricing, and financial modeling. She has evaluated structured investments in tax litigation, conducted financial statement and valuation analysis in bankruptcy litigation matters, and estimated cost of capital for regulated utilities. Dr. Kumar holds a Ph.D. in Financial Economics from the MIT Sloan School of Management.

Telephone: +1.617.864.7900 **Email:** Pavitra.Kumar@brattle.com

Dr. Michael Goldstein, a senior advisor to *Brattle*, is a Professor of Finance and Faculty Director for The Stephen D. Cutler Center for Investments and Finance at Babson College. His primary area of expertise is securities market structure issues, execution costs, and trading. Dr. Goldstein holds a Ph.D. and M.A. in Finance and an MBA in Finance and Management from The Wharton School at the University of Pennsylvania.

Telephone: +1.617.864.7900 **Email:** Michael.Goldstein@brattle.com

Mr. Frank Graves, a principal at *Brattle*, is an expert in finance and regulatory economics. He advises clients in securities litigation suits, special purpose audits, tax and contract disputes, investment planning, and risk management issues. He has testified before state and federal courts, the U.S. Federal Energy Regulatory Commission, and various state regulatory commissions. Mr. Graves holds an M.S., with a concentration in Finance, from the MIT Sloan School of Management.

Telephone: +1.617.864.7900 **Email:** Frank.Graves@brattle.com

Dr. Lynda Borucki, a principal at *Brattle*, is a financial economist with experience providing advice and expert testimony on the application of corporate finance and economics in both litigation and strategic engagements. She develops and critiques damage claims; values assets, businesses, and securities; and evaluates structured finance transactions. Dr. Borucki holds a Ph.D. and M.S. in Managerial Economics and Decision Sciences from Northwestern University.

Telephone: +1.617.864.7900 **Email:** Lynda.Borucki@brattle.com

44 Brattle Street
Cambridge, MA 02138
Telephone +1.617.864.7900
Facsimile +1.617.864.1576

Suite 1140
353 Sacramento Street
San Francisco, CA 94111
Telephone +1.415.217.1000
Facsimile +1.415.217.1099

Suite 1200
1850 M Street, NW
Washington, DC 20036
Telephone +1.202.955.5050
Facsimile +1.202.955.5059

The Brattle Group Limited
Rond Point Schuman 6
Box 5
1040 Brussels
Belgium
Telephone +32.2.234.77.05
Facsimile +32.2.234.79.05

The Brattle Group Limited
Halton House
20-23 Holborn
London EC1N 2JD
United Kingdom
Telephone +44.20.7406.7900
Facsimile +44.20.7406.7901

The Brattle Group Limited
Torre Europa
Paseo de la Castellana 95, Planta 15
28046 Madrid
Spain
Telephone +34.91.418.69.70
Facsimile +34.91.418.69.99