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What is High Frequency Trading?

The impact of “high frequency trading” or “HFT” on U.S. equity markets has generated significant attention in recent years and increasingly in the last few months. Although HFT strategies now execute approximately 50% of the volume in U.S.-listed equities,¹ there is still a limited understanding of how these strategies work in practice. Through this report, the Committee on Capital Markets Regulation seeks to shed further light on HFT to inform public debate and form a basis for future policy reforms. The purpose of this statement is not to examine whether HFT is good or bad for markets or investors.

This report first sets forth the characteristics that are common among HFT strategies, market making and arbitrage, followed by a discussion of how HFT strategies relate to trading strategies that have traditionally existed in equities markets. Next, the report addresses the issue of HFT profits, noting that the high degree of competition among high frequency traders leads to very low margins, which do *not* generate consistent trading *profits*. Finally, the report sheds additional light on HFT strategies that regulators should seek to identify and prevent.

There is an opportunity for the targeted improvement of the current regulatory structure to ensure the safety and soundness of our markets. The Committee on Capital Markets Regulation is currently undertaking a review of U.S. equity market structure with a focus on HFT, exchanges, dark pools, broker-dealer internalization, and decimalization, and intends to issue a comprehensive report with policy recommendations for improving our equity markets.

HFT Characteristics

Due to the widespread accessibility of the highest speed execution and data services, there are a multitude of different types of institutions with traders using HFT strategies.² Indeed, even retail and institutional investors have access to some of the highest speed execution services through their broker-dealers. Thus, an informative analysis of HFT should not focus on identifying certain institutions that engage in HFT strategies as HFT *firms*, instead it should seek to clarify the functional characteristics that appropriately classify a strategy as “HFT.”

According to the Securities Exchange Commission (“SEC”), these common functional characteristics, include: (1) use of extraordinarily high speed and sophisticated programs for generating, routing, and executing orders; (2) use of co-location services and individual data feeds offered by exchanges and others to minimize network and other latencies; (3) very short timeframes for establishing and liquidating positions; (4) submission of numerous orders that are cancelled shortly after submission; and (5) ending the trading day in as close to a flat position as possible (that is, not carrying significant, unhedged positions overnight).³

¹ World Federation of Exchanges, *Understanding High Frequency Trading* 1 (May 2013), available at http://modernmarketsinitiative.org/wp-content/uploads/2013/10/WFE_Understanding-HFT_May-2013.pdf.

² U.S. Securities and Exchange Commission, *Concept Release on Equity Market Structure* 1, 45 (Jan. 14, 2010).

³ *Id.*

The Market Maker Strategy

A substantial portion of HFT trades are part of a market making strategy.⁴ However, in order to understand the role of HFT in market making, an explanation of the traditional market making strategy is necessary.

Stock exchanges have always had market makers, whether called market makers or specialists as on the old New York Stock Exchange (“NYSE”). Market makers perform the essential function of meeting the liquidity demands of fundamental investors who cannot efficiently trade directly with each other.⁵ For example, a fundamental investor wishing to buy 100 shares of XYZ may not be immediately matched with another fundamental investor wishing to sell 100 shares of XYZ, because these investors come to the market at different times or don’t agree on a price at that moment. That is, at 9:42:11 Vanguard may want to buy 200,000 shares of Microsoft, but another fundamental investor, such as Fidelity, is unlikely to want to sell that exact amount in that same second. Therefore, to ensure immediacy of execution, a market maker intermediates such a trade. Market makers do so by constantly displaying quotes for a given set of stocks. They display a “bid” price to buy a stock from investors and an “ask” or “offer” price to sell a stock to investors. If an investor agrees to buy at the “ask” or sell for the “bid,” then market makers are required to abide by their quotes. As a result, investors are able to enter or exit positions immediately at the best available prices.

Market makers determine the “bid” and “ask” quotes based on their assessment of the immediate supply and demand for each security. By buying for the “bid” price and selling at the higher “ask” price, they seek to profit from the difference between the “bid” and the “ask” prices without forming expectations about longer-term movements of the stock price.⁶ For example, a market maker aims to “bid” \$10.00 and sell at the “ask” of \$10.04. Given the constant fluctuation of supply and demand for stocks and the fact that market maker orders are not executed immediately, market makers must constantly update their bid and ask quotes based on new public information.⁷

The transaction cost to an institutional or retail investor of buying or selling a stock largely depends on the difference between the bid and the ask prices, or the “bid-ask spread.” For example, if market makers are bidding \$10.00 for a stock and asking \$10.04, then the transaction cost to a buyer or a seller is generally defined as half of the spread, so \$0.02/share in this case.

The bid-ask spread that a market maker quotes for a stock is determined by the financial risk that the market maker has to bear to hold a position in that stock. For example, if a stock is highly liquid (that is, there are a lot of buyers and sellers) then the bid-ask spread will be narrow, because the market maker’s holding period for the stock will be short, so the potential risk of loss due to fluctuations in the fair market value will be low. Similarly, if the price of the stock has

⁴ Credit Suisse, *U.S. Market Structure, HFT 101 with Tradeworx* 1, 4-6 (May 20, 2014).

⁵ U.S. Securities and Exchange Commission, *Concept Release on Equity Market Structure* 1, 49-50 (Jan. 14, 2010).

⁶ *Id.* at 49, 53.

⁷ U.S. Securities and Exchange Commission, *Equity Market Structure Literature Review, Part II: High Frequency Trading by Staff of the Division of Trading and Markets* 1, 7 (Mar. 18, 2014).

been stable in the past (that is, low volatility in the stock's value) then market makers will be able to offer lower spreads, since they bear less risk that the price will change during their holding period.

Competition between market makers is highly valuable to investors, because it reduces transaction costs. The competitiveness of a market maker depends on its ability to minimize financial risk. Market makers do so by using all available public information to reach the best determination of the immediate supply and demand for a stock, allowing a market maker to enter and exit positions more reliably. For example, a sophisticated market maker that can reliably manage its financial risk would be able to buy at a bid of \$10.01 and sell at an ask of \$10.03, whereas a less efficient market maker might have to buy at a bid of \$10.00 and sell at an ask of \$10.04. As a result of the first market maker's greater sophistication and ability to quote a narrower spread, an institutional or retail investor seeking to buy or sell that stock would save \$0.01/share. Considering that turnover in the U.S. stock market is over two trillion shares per year, these pennies add up.

HFT Market Making

As noted above, the primary way that market makers have always competed to offer the lowest bid-ask spread is by having the most up-to-date public information regarding supply and demand for a security, so they can revise their prices accordingly. In the past, NYSE specialists would do so simply by observing selling or buying pressure building up on exchange floors.⁸ NYSE specialists also had exclusive access to information regarding bid and ask orders on the NYSE and a monopoly on market making.

HFT market makers now use high-speed public data feeds to remain informed regarding all outstanding bid and ask quotes on exchanges and trade executions on and off exchange. HFT market makers use algorithms to assess the significance of each quote and trade execution for the supply and demand for that security. HFT market makers are also able to use their high-speed programs to constantly update their quotes. As a result, HFT market makers are able to reduce the likelihood that they will buy or sell a stock at stale prices and thus manage their financial risk more effectively than traditional market makers.

An active debate exists regarding the liquidity enhancements provided by HFT market makers. Some argue that HFT market makers increase liquidity during normal times, only to pull it during times of stress, thus exacerbating market disruptions.⁹ However, others have more recently shown that HFT market makers in aggregate are net suppliers of liquidity during market disruptions, thus improving market stability.¹⁰

Access to public information regarding trade executions, outstanding bid and ask quotes and the ability to quickly execute orders is also relevant to institutional and retail investors

⁸ Cliff Asness et al., *High Frequency Hyperbole, Part Deux* 1, 3 (May 22, 2014).

⁹ See e.g., Andrei Kirilenko, Albert Kyle, Mehrad Samadi & Tugkan Tuzun, *The Flash Crash: The Impact of High Frequency Trading on an Electronic Market*, working paper (Jan. 12, 2011).

¹⁰ See Jonathan Brogaard et al., *High-Frequency Trading and Extreme Price Movements*, working paper (Nov. 2014).

seeking to minimize transaction costs. In the past, floor traders could observe buying and selling pressures building up on the floor immediately and adjust their quotes accordingly. Fundamental investors, who were not on the floor, had to wait tens of seconds to change or cancel their orders, and could not see the bid and ask quotes on the floor. This would increase transaction costs for investors, because when large sell orders would arrive on the trading floor, specialists could cancel their bids, while the bids of investors would end up providing the liquidity to these sellers at adverse prices.¹¹

SEC rules require exchanges to offer all investors and traders access to the highest speed data and co-location services at a reasonable and equal price,¹² and over 90% of investors now have effective access to the highest-speed exchange data feeds and highest speed execution services.¹³ This provides investors with access to information that allows them to avoid executing orders at stale prices.

Despite the increased sophistication of HFT market makers, they still regularly enter into “losing” trades, where the price moves against them after they execute a trade, thus forcing them to exit the position at a loss. This often occurs due to normal market fluctuations. HFT market makers also make losing trades because HFT market makers regularly trade with large institutional investors who know that their large orders will increase or decrease the short-term price of a stock, but are able to conceal the size of their order. Institutional investors do so by using algorithms to break up large orders in a random manner, making them virtually indistinguishable from small orders.¹⁴

By concealing the size of their orders, institutional investors can reduce their transaction costs. For example, suppose an institutional investor seeks to sell ten million shares of XYZ. If it were to place one large order for all ten million, then HFT market makers, like traditional market makers, would decrease their bid price for XYZ, knowing that the increased supply from the institutional investor would reduce the price of the stock. However, if the institutional investor breaks up the order into smaller sizes and spreads those orders out over time and across execution venues, the HFT market maker will be less likely to reduce its bid price in time to avoid losses. Although *Flash Boys* criticizes HFT market makers for responding to large orders by immediately adjusting bid and ask price quotes, this is precisely how traditional market makers have responded to increased demand for a stock since the beginning of market making.

HFT market makers seek to manage this risk by quoting a bid-ask spread that is sufficiently wide to compensate for the risk that the market will move against them after the trade. However, when HFT market makers trade with retail orders, they know that they are less likely to be trading with a large order disguised as a small order. As a result, bid-ask spreads for retail investors are lower than bid-ask spreads for other investors. Retail brokerages send customer orders directly to wholesale brokers who act as market makers for retail investors by immediately filling retail orders. As a result, if a stock has a bid of \$10.00 and an ask of \$10.04

¹¹ Cliff Asness et al., *High Frequency Hyperbole, Part Deux* 1, 3 (May 22, 2014).

¹² U.S. Securities and Exchange Commission, *Concept Release on Equity Market Structure* 1, 58 (Jan. 14, 2010).

¹³ Rosenblatt estimate based on U.S. exchange statements. See also Manoj Narang, *A Much-Needed HFT Primer for Michael Lewis*, Institutional Investor (Apr 7, 2014). Co-location and direct data feeds are in “very widespread use.”

¹⁴ Blackrock, *U.S. Equity Market Structure: An Investor Perspective* 1, 4 (Apr. 2014).

on an exchange, then a retail investor trading through a retail brokerage often gets orders filled at slightly better prices — perhaps \$10.01 and \$10.03. For example, the average spread for the most liquid stocks are one cent on an exchange,¹⁵ but retail investors typically pay less than one cent spreads for trades in these stocks filled by wholesale broker-dealers.¹⁶

The Arbitrage Strategy

Arbitrage strategies are also a fundamental component of securities markets. Arbitrage opportunities arise when the same asset trades on multiple markets at different prices, or when two related assets trade at different prices. Such price divergences can occur for various reasons. For example, different types of market participants may be trading more in one market versus another.

Whenever prices between the same or related assets diverge, arbitrageurs profit by simultaneously buying the lower priced asset and selling the higher priced asset, until prices converge. These arbitrage strategies improve price discovery, because they bring prices of securities more in line with fundamental values. Arbitrageurs receive compensation for obtaining information and restoring prices to equilibrium.¹⁷

However, in practice, the execution of arbitrage strategies is not entirely risk-free. Holding arbitrage positions requires capital and the timing of price alignment cannot be predicted, with prices potentially diverging even further.¹⁸ Arbitrageurs seek to manage their exposure to temporary price divergences. However, much like market makers, their ability to do so is limited by the fundamental supply and demand for the security.

Statistical Arbitrage

Although statistical “arbitrage” is not a pure arbitrage strategy in the fundamental sense, because it does not involve securities with identical future cash flows, it also improves price discovery in securities markets and existed well before HFT.

Statistical arbitrage generally refers to trading one or more instruments based on a statistical analysis of market data. Statistical arbitrageurs identify securities that have historically been correlated with each other (i.e. traded within a certain price range of each other) as well as individual securities that exhibit consistent patterns of trading activity. When prices diverge from these historical and fundamental trading patterns, statistical arbitrageurs assess whether the divergence from historical price movements is temporary or whether it is permanent.¹⁹ For example, a *temporary* price change could be due to market-wide volatility, rather than any

¹⁵ See James Angel et al., *Equity Trading in the 21st Century: An Update* 1, 5 (Jun. 21, 2013).

¹⁶ See Citadel, *The Citadel Conversation Q1 2013* 1 (2013), available at https://www.citadelsecurities.com/_files/uploads/sites/2/2013/06/The-Citadel-Conversation-with-Larry-Tabb-and-Jamil-Nazarali.pdf.

¹⁷ Sanford Grossman & Joseph Stiglitz, *On the Impossibility of Informationally Efficient Markets*, 70.3 *The American Econ. Rev.* 1 (Jun. 1980).

¹⁸ Andre Shleifer & Robert Vishny, *The Limits of Arbitrage*, LII.1 *The Journal of Finance* 1 (Mar. 1997).

¹⁹ Jonathan Brogaard et al., *High Frequency Trading and Price Discovery*, European Central Bank Working Paper Series 1, 5 (Nov. 2013).

change in the expectation of the future cash flows of the security itself. Statistical arbitrageurs then trade against temporary price changes, seeking to realign the security with its previous price range, capturing any pricing differences in the process.²⁰

These arbitrage strategies improve price discovery, because statistical arbitrageurs expend resources to seek out additional information and analyze its meaning for the price of the security. They then incorporate this information and analysis into the effective price of a security by buying or selling that security. As a result, the price of the security will reflect more information.²¹ This is beneficial for capital markets, because more informative stock prices can lead to better resource allocation in the economy.²²

HFT Arbitrage

HFT arbitrage strategies seek to capture pricing inefficiencies in precisely the same manner as traditional and statistical arbitrageurs. However, their ability to do so is improved by faster data feeds regarding trade executions and orders, which are available to all investors, and other information relevant to the price of a security. HFT arbitrageurs also have increasingly sophisticated algorithms and systems for quickly analyzing this market data. Additionally, HFT arbitrageurs' high-speed connections to markets allow them to enter and exit positions quicker than in the past, so they are better able to reduce financial risk from holding a security if prices continue to diverge.

One example of HFT arbitrage involves securities that derive their value from underlying assets.²³ The most prevalent examples are exchange-traded funds ("ETFs"), which are investment funds that trade on stock exchanges and hold assets such as stocks, commodities, or bonds. Another example is futures, like the "E-mini S&P," which derives its value from the components of the S&P 500 index.

Because ETFs, futures and their underlying assets trade separately, their prices can diverge at times. Whenever this occurs, arbitrageurs know that this price divergence is only temporary, since their fundamental value must be the same. HFT arbitrageurs will therefore seek to capture this price difference. For example, suppose the price of the SPDR S&P 500 ETF exceeds the price of the basket of stocks in the S&P 500. After adjusting for anticipated transaction and/or financing costs, arbitrageurs will sell shares of the SPDR S&P 500 and buy shares of the stocks in the S&P 500, until the prices align.

This sort of trading strategy is beneficial to investors because it assures them that the prices of ETFs and futures accurately reflect the prices of their underlying assets and therefore that investors can enter or exit their position in a timely manner at the right price. Currently, the median time until price divergence disappears for ETF strategies is typically less than five

²⁰ *Id.*

²¹ Andre Shleifer & Robert Vishny, *The Limits of Arbitrage*, LII.1 *The Journal of Finance* 1 (Mar. 1997).

²² Jonathan Brogaard et al., *High Frequency Trading and Price Discovery*, European Central Bank Working Paper Series 1, 31 (Nov. 2013).

²³ U.S. Securities and Exchange Commission, *Concept Release on Equity Market Structure* 1, 53 (Jan. 14, 2010).

minutes.²⁴ Prior to the advent of ETFs, which now hold nearly \$1.7 trillion in assets under management,²⁵ retail investors could only invest in diversified strategies or certain asset classes, including bonds or commodities, through mutual funds that only offer liquidity twice a day and often have higher fees associated with them. Now, investors can enter or exit their position in ETFs at any point in the trading day. Investors can enter or exit positions in the E-mini S&P twenty-three hours a day.

In short, HFT arbitrage strategies enable arbitrageurs to identify and trade against mispricings faster than ever before. As a result, HFT strategies reduce the length of time that mispricings between identical or related securities exist, enabling investors to enter and exit positions at prices that better reflect the fundamental value of an asset.

HFT Profits

HFT strategies have been publicly criticized because of certain traders' ability to earn consistently positive *daily trading revenue*. These critics suggest that this is evidence that high frequency traders are "skimming" pennies off of each trade and thereby increasing costs for institutional and retail investors.

However, consistent positive daily trading revenue for the most successful high frequency traders does not necessarily correspond with net profit for that trader. Executing these high-speed strategies is extremely costly, including salaries for quantitative experts and technological infrastructure spending. For example, McDonald's earns positive daily revenue from selling hamburgers, however that does not mean that they are earning a profit after accounting for all expenses, nor does it mean that they are cheating customers. Although high frequency traders account for 50% of the 6.2 billion in daily trades in the U.S. stock market²⁶ and comparable participation in foreign exchange and commodities markets, margins on this huge volume of trading are incredibly low as the HFT industry's aggregate profits for U.S. equities was approximately \$1.3 billion in 2013.²⁷ The high degree of competition in the industry ensures that high frequency traders are not earning out-sized "economic rents" from investors.

Additionally, as discussed in detail above, high frequency traders do not always win on each individual trade. Some trades are winners, while some are losers. The goal of a high frequency trader is to average more winners than losers across the high volume of trades they enter into on a daily basis. By the law of large numbers, if the number of trades gets sufficiently large, then the individual trade winning percentage becomes a highly reliable indicator of the proportion of winning trades at the end of each trading day. For example, if an HFT market maker gains the spread on 52.5% of trades, loses the spread on the other 47.5%, and does 10 trades a minute, it will have a losing day once every eight years. A winning percentage of 52.5% on each trade does not indicate an unfair market, but rather an appropriate fee earned by market makers for providing liquidity. The same applies in the case of ETF arbitrage.

²⁴ Ben Marshall et al., *ETF arbitrage: Intraday evidence* 1 (Nov. 16, 2010).

²⁵ Inv. Co. Inst., *2014 Fact Book* 1, 55-69 (2014).

²⁶ Carol Clark, *Market Structure, Incentives, and Fragility*, Chicago Fed Letter (March 2014). Figure 1.

²⁷ Matthew Philips, *What Michael Lewis Gets Wrong About High Frequency Trading*, Bloomberg BusinessWeek (Apr. 1, 2014). Based on TABB group estimate.

Illegal trading strategies

According to *Flash Boys*, high-speed data feeds and the co-location of trading machines close to exchanges provide high-frequency traders with informational and execution advantages over institutional and retail investors. Michael Lewis contends that this allows high-frequency traders to see investor orders and trade ahead of these investors in a manner that is comparable to the illegal strategy of a broker “front running” an order by its customer. However, these criticisms fail to acknowledge that high-frequency traders only trade on *public* information and there is nothing illegal about doing so. Indeed the whole purpose of implementing rules that require certain quotes, orders, and trades to be publicly reported in a manner that makes the data available to all market participants at the same time is to enable the market participants to react to this data once it is published. Moreover, as noted above, HFT market making and arbitrage strategies depend on these *public* high-speed data feeds and co-location services to enhance *legal* strategies that have always contributed to well-functioning equities markets. Moreover, high-speed data feeds and co-location are not just used by high frequency traders, as 90% of market participants access these services, because exchanges are required to make high-speed data feeds and co-location available to all market participants at the same, reasonable cost.

However, certain practices by high frequency traders do attempt to manipulate market prices with illegal trading strategies,²⁸ but these strategies are no different than traditional market manipulation strategies and there is no evidence that the rise of HFT has led to an increasing incidence of market manipulation, as these strategies represent a small fraction of the trades enacted by high frequency traders. Indeed, the incidence of HFT-based market manipulation vs. “old fashioned” market manipulation (like penny stock schemes, pump and dump, etc.) is very low.

These illegal strategies involve human traders using their high-speed connections to the market to manipulate stock prices, with the intent of deceiving other market participants. Although the names for these trading strategies are different, including “spoofing,” “layering” and “momentum ignition,” these names are all used to refer to similar strategies.

These strategies involve traders seeking to deceive other market participants regarding their trading interest. For example, a trader might offer to buy a substantial amount of stock in order to increase the short-term price of that stock. In reality, this trader wants to sell the stock and then uses his high-speed connection to quickly cancel his orders to buy and sell their stock at the higher price. Because HFT market maker algorithms are buying and selling stocks in a rapid and automated manner, they are susceptible to these strategies.

However, regulators are well positioned to identify these strategies because their “order trail” is very distinct. For example, regulators can see that a trader is putting a substantial amount of buy orders into the market then cancelling those orders precisely when they sell the same stock at a higher price.

²⁸ U.S. Securities and Exchange Commission, *Equity Market Structure Literature Review, Part II: High Frequency Trading by Staff of the Division of Trading and Markets* 1, 8 (Mar. 18, 2014).

The SEC and CFTC have recently identified and penalized some traders using these illegal strategies²⁹ and their ability to do so will only be enhanced once the Consolidated Audit Trail (“CAT”) is implemented. The CAT will be a data repository of all orders, cancellations, modifications, and trade executions for all exchange-listed equities and equity options across all U.S markets, enabling regulators to see the entire order history of all high frequency traders.³⁰

Conclusion

High frequency trading strategies are consistent with trading strategies that have always existed in securities markets. Through high-speed access to data, algorithms that can assess the significance of the data, and the ability to constantly update prices accordingly, high frequency traders have improved upon these traditional trading strategies. Moreover, investors and regulators are well positioned to identify and penalize illegal trading strategies, whether conducted by high frequency traders or non-high frequency traders. Finally, the consistently positive daily trading revenue for certain high frequency traders is not evidence of an unfair market: margins are very low, competition is very high and these high frequency traders provide liquidity and price discovery services to the market.

²⁹ See Andrew Harris & Matthew Leising, *High-Speed Trader Accused of Commodity Market ‘Spoofing,’* Bloomberg (Oct. 2, 2014); see also John Mccrank, *SEC Targets 10 firms in High Frequency Trading Probe - SEC Document*, Reuters (Jul. 17, 2014).

³⁰ *SEC Rule 613: Consolidated Audit Trail* (2014), available at <http://catnmsplan.com/>.