



High Frequency Trading

An Introductory Guide

What is High Frequency Trading?

High Frequency Trading (HFT) is a subset of algorithmic trading; one that relies on a large number of small orders sent into the marketplace at high speeds. A key ingredient of HFT is speed, another is access to venues.

In order to make money, high frequency traders have to be able to interpret market factors and move faster than other investors - and execute their trades in microseconds in varied venues. HFT shops combine the ability to trade on market information (with risk-reducing strategies) more quickly than other investors, with payments offered to them by exchanges for

providing liquidity, in order to generate substantial profits. Algorithms, computer programs designed to digest and act on market information, conduct the trading for HFT firms.

Exchange Trading Basics

A securities (or commodities) exchange is a market venue that brings together counterparties providing an opportunity to "exchange" their shares at an acceptable price. The exchange manages order flow by priority of type and time according to regulated rules, and offers "quotes" of information describing to potential counterparties the availability of different numbers of shares at determined prices. Exchange performance is tracked by examining

the market transactions of quotes matching for order flows – to trade executions, by tracking the volume(s) of shares traded by the volatility of price changes. That performance data is market information that helps inform traders and researchers on the quality of various exchanges.

An exchange is only a valuable place to buy and sell shares if there is a ready counterparty to a trade. An investor seeking to purchase shares in a particular company, or contracts of a commodity, would not be satisfied with an exchange that simply parked his or her order until another customer came to that market to sell. The primary value of an organized exchange is created by the regular flow of transactions in different issues. That provides timely execution to those looking to trade, and price discovery to the trader and other market researchers based on related consequences of those trades. The exchange facilitates quote and order flows, and subscribing “market makers” facilitate trading at the exchange.

A market maker competes for customers' orders by maintaining a two-sided book of trades, listing the numbers of shares that they are willing to sell (at the “ask”) or buy (at the “bid”). The difference between the bid and ask is a “spread” that is earned by the market maker for being willing to maintain an inventory that facilitates trading. The size of the spread changes based on supply and demand, but it should (at least partially) protect the market maker from consistently losing money to investors that have better, or more timely, information about the security than the market maker does.

The market maker provides “liquidity” to the market by serving as a go-between for those who buy, and those who sell – by building and maintaining inventory in marketable securities. In effect, by providing more opportunity to exchange orders in a managed market, more liquidity is available in the market.

There are two basic types of orders that an investor can submit: a *market order* or a *limit order*. A third order type is the *stop order*, which serves a financial risk management purpose.

The market order guarantees that the transaction will take place, but the price at which shares will be bought or sold is unknown. Essentially, a market order is an order to buy a set number of shares at whatever the prevailing market price is.

A limit order may not be executed, but it allows the investor to specify a certain price (or better) at which shares will be bought or sold, thus guaranteeing price certainty in exchange for execution certainty.

Stop orders (aka “stop loss”) are often utilized to assess market momentum or volatility. This practice is sometimes referred to as “fishing” the market; and is similar to small volume orders (that are not cancelled) which are often used for “price discovery” or to interpret the “depth of market” in certain securities. When a stop price is reached, the order becomes a market order. Investors will use a buy-stop order to limit a loss on “short” sells by entering at a price above the current market price. Conversely, investors will use a sell-stop order (at a stop price below the current market price) to limit losses on stocks they own.

Stop orders represent a basic strategy that traders have borrowed from investors to create risk reduction and management of their inventory with automated “hedging” techniques. Those techniques are employed as fundamentals of HFT and the varied elaborations of these order types merely represent other methods of discovering depth, momentum, and profitability.

Exchanges typically pay a small rebate to those who post standing orders (like limit orders) and charge a fee to those that trade at the displayed bid or ask (like market orders). These fees are often referred to as 'maker-taker fees' and are designed to further encourage standing liquidity, which makes the exchange a more attractive market venue to investors.

It is important to note that many orders that are submitted to market venues are quickly cancelled. That is a technique that was popular for price discovery until exchanges realized the negative impacts on inventory and began to exclude serial perpetrators of those activities.

The Rise of HFT

Several factors brought about the rise of HFT. First among those factors is the slow decline of in-person floor trading, where human market makers would execute buy and sell orders, facilitating the flow of trading by providing a ready counterparty for those looking to trade (sometimes even by functioning as a counterparty in order to maintain inventory and market momentum). Exchanges paid market makers rebates for providing liquidity, thus compensating them for the service they were providing to people who wished to trade in a

particular security. Two exchanges (NASDAQ and NYSE) dominated the US markets, and most trading occurred in those venues and was limited to trading hours of those geographic regions.

In 1998, then chairman Arthur Levitt pushed Regulation Alternative Trading Systems (ATS) through the SEC to combat the stronghold that NASDAQ and the NYSE had on trading. ATS allowed market access for electronic platforms, providing investors, among other things, the opportunity to trade after-hours when markets were closed. This was an important evolution that helped to stimulate the development of trading automation and systems.

In 2001, the rise of electronic trading platforms led to another significant change: shares would no longer be quoted in fractional form, but would be quoted using decimals instead. The minimum spread that market makers stood to make under the fractional system was 6.25 cents, using decimals this margin was cut down to a penny. While a disadvantage to market makers, this new rule created more liquidity, as it decreased the likelihood that an investor would be trading at a disadvantage to the market maker.

Even after this change, brokers were still matching orders internally, and pocketing the spread. Investors had limited insights into whether they were receiving “best execution” of their orders, in priority, price, or fulfillment. Regulation National Market Systems (NMS), released in 2007, helped put a stop to this practice. It required that all trades be listed electronically, thus linking markets together, and

required that a *National Best Bid and Offer* (NBBO) price be identified and used so that investors could be guaranteed execution at the lowest ask and highest bid available. Through providing a system for a single market price, and linking markets using an electronic platform, NMS made floor traders less necessary; what was once done by man could now be done by machine. By 2007, most of the exchanges had transitioned to electronic order matching systems, and the human element, which had previously been so important, was almost gone.

The rise of electronic trading platforms, more competition among exchanges, and the rebates available for market making activities built into those exchanges, created the opportunity for HFT systems to overtake human trading.

How it Works

Market makers can expect to earn the spread in exchange for making a market. The more trades, the more spreads that are earned. This is an area in which HFTs were designed to make money. As more orders are submitted and trades are transacted, the spreads become tighter. At tight spreads a computer can execute more transactions, more quickly, than a human – and earn profits more efficiently.

Exchanges also generally pay a small rebate to those who are providing liquidity – traders who transact in non-marketable orders which are then turned into marketable orders by other traders taking the opposing side at or above the lowest offer (thereby removing liquidity from the exchange). The 'patient traders' who leave standing orders at the Exchange are paid a rebate, and the 'active traders' are charged an

access fee to trade against the orders that the 'patient traders' have left at the Exchange. The connectivity of markets allows HFTs to take advantage of these conditions to make money, while simultaneously providing a valuable service to markets by providing liquidity, in much the same way that floor trading market makers once did. With more orders and trades, there is more liquidity in the market – and opportunity.

HFT firms rely on speed, which comes from many sources, chiefly from the use of algorithms to create and route orders and/or execute trades. Additionally, co-locating their servers in direct proximity to the exchanges allows them to have personal data feeds from the exchanges and get faster market information. Proximity to the servers also allows them to reduce latency, which is the amount of time trade execution takes. All this allows HFT firms to react quickly to market information and to engage other traders rapidly with numerous small(er) orders.

HFTs are also able to make money by staying ahead of other traders. Their proximity to the Exchanges allows them to very accurately predict when a particular quote is about to roll. As mentioned above, supply and demand determine the bid-ask spread; suppose that ABC Inc. has a bid of \$10 for 10,000 shares and an ask of \$10.01 for 10,000 shares. New participants come into the market, and bring with them buying pressure on the stock, such that the bid is \$10 for 5,000 shares and the ask is \$10.01 for 30,000 shares. People are transacting at the bid, meaning that the stock price is likely to go up. HFTs will use this information, gained via their high speed access to the exchange, to make money. HFTs will cancel their remaining

bids at \$10, buy all the shares they can at \$10 from slower traders, and prepare to sell them at the new higher price for an immediate profit. These techniques work as long as the HFT orders stay on the top of the order queue, which is often accomplished via custom order types that exchanges have devised to attract HFT clients (like the now famous hide-not-slide order).

It is important to remember that, like traditional market makers, HFTs are proprietary traders; they are trading their own accounts and not investing money for clients. This means that an HFT shop is only beholden to making a profit for itself and has no other suitability or investment advisory burdens that it must meet.

Just like traditional market makers, empirical evidence shows that HFTs have helped to reduce spreads, adding liquidity to the market and alleviating the dangers of market fragmentation. However, because they typically submit numerous small orders, they may not be adding depth to the market like a traditional market maker would.

HFTs are only as good as their algorithms, which in some cases can be poorly designed, or can fail to act in the way they were intended to. Trading in IBM, Apple, McDonald's and Coca-Cola all displayed easily discernible trading patterns on July 19, 2012. These patterns were discovered to be caused by a "dumb" algorithm that was not being properly monitored. The Flash Crash of 2010 was (arguably) caused by malfunctioning algorithms. Knight Capital, a major player in the world of HFTs, lost \$440 million due to a glitch in one of its trading

systems on August 1, 2012. HFT programs also took the markets for a short sharp ride on April 23, 2013 when a hacked AP tweet announced that the White House was under attack and President Obama had been injured. Moments later when the AP announced it had been hacked, the markets rebounded immediately. These are only a few examples of the potential impact that HFT programs can have on markets, which are now sensitive to their activities due to their reliance on HFTs for liquidity.

HFT Strategies

While there are many strategies employed by HFTs, and each HFT may itself employ multiple strategies, the following are several common strategies employed by most HFT firms:

1. Liquidity Detection - HFTs see investors attempting a transaction on one exchange, and then race them to the other exchanges before they can complete their full order, driving up (or down) the price ahead of them. Finding out what investors intend to do is uncovered in a number of ways. The first has to do with order types. HFTs account for 99% of all orders, but only about half of all trades. Those other small (and numerous) orders are not actually designed to trade, but are like bait laid out to determine what other traders may be intending to do. The second is via the exchange rebate system, an example of which is BATS. The BATS exchange offers a rebate program opposite to most exchanges, they pay people to take liquidity rather than provide it. This means that when a large broker-dealer has an order, they have an incentive to go buy shares on BATS first, since they will get a rebate for their trades.

Even if the entire order is 5,000 shares, and BATS only has a quote for 500 shares; that first 500 will be purchased first on BATS. HFTs plugged into BATS can then try and figure out if the remaining order is large, and race the buyer to the other exchanges, making purchases and driving the price away from the initial buyer.

2. Rebate Trading / Market Making - HFTs use the complexity of various rebate programs offered by the exchanges to generate income for themselves without actually providing any of the liquidity that the rebate programs are designed to incentivize them to do.

3. Leveraging Structural Differences - Price changes occurring a millisecond earlier on one exchange are used to drive profitable trades on another exchange. ABC Inc. is trading at 10-10.01 when a big seller dumps their position on the NYSE causing the quote to change to 9.98-9.99. HFTs will buy at 9.99 on NYSE and sell at 10 on the other exchanges.

4. Statistical Arbitrage - HFTs exploit momentary inconsistencies or imbalances in asset prices, trading to take advantage of differentials between (historically) correlated securities and markets. Some firms trade on momentum or technical-based strategies as well.

5. Filter Trading - HFT algorithms search for assets that show significant changes in price movements and volume, using these indicators to trade off a prediction that the asset will rise/fall accordingly.

HFT, Exchanges, and Banks (Dark Pools)

The relationship between HFTs and exchanges is quite strong. Exchanges need HFTs for liquidity purposes, and as such have been willing to create order types and rebate programs that create systemic advantages for HFTs.

HFTs also benefit from their relationships with other banking entities, whom they can pay for direct access to customer order flow and/or the right to execute customer trades for that bank, enabling them to pursue the strategies noted in the previous section. Once an order is submitted (to an online broker, for example), the information about the investor's intentions is up for sale to HFTs, giving them an inside look at what the market might look like a few seconds later, more than enough time to execute profitable strategies given their speed and access to the exchanges.

Many banks also run internal dark pools, which are designed to manage trades in-house and off the exchanges. The benefit of trading in the pool to the client comes from not having to disclose large or sensitive orders to the public exchanges where other investors can learn what you intend to do and then trade ahead of you. Dark pool trades are not new; internal trade crossing off of exchanges is an old practice, used primarily by institutional investors trying not to move the market with their orders. HFTs have been paying for access to banks' dark pools, giving them the ability to tap additional information on order flow, ping around in the 'dark' until they find a large order that they can then trade ahead of in public markets. About 40% of all U.S. stock trades occurred in dark pools in 2014, up from just 16% in 2008.

Current

Litigation/Investigation

There has been a great deal of scrutiny into the close relationship between HFTs, exchanges and banks, especially regarding the ability to access order flow information, and the system of advantages built into trading platforms. New York Attorney General Eric Schneiderman has been very active in subpoenaing information from HFT firms, exchanges, and other alternative trading platforms in trying to uncover the extent of the relationship between the parties, and to determine if any illegal activity has taken place as a result. The SEC, CFTC and FBI are all conducting their own HFT-related investigations and inquiries into automated trading activity. NYSE has already announced a \$4.5 million settlement with the SEC related to its co-location practices, which had allowed HFT computers to be placed in close proximity to its own data center and matching engine.

Chairwoman of the SEC Mary Jo White has also announced that the agency will be conducting a comprehensive review of its own rules (like Reg NMS) that may be contributing to market fragmentation. The SEC will also work with FINRA to expand disclosures related to trading within dark pools. FINRA has begun to report aggregate trade information on dark pools, covering trading in S&P 500, Russell 1000 and certain ETFs for now, with plans to expand reporting over time. The new data reporting, and any further actions taken by the SEC and FINRA, will bring additional transparency to off-exchange trading.

Customers also appear to be taking action themselves: Fidelity, which manages about \$2 trillion in assets, has announced that it will create a new trading venue called Sakura, distinct from the dark pool it operates called CrossStream.

Exchanges are also evaluating their rules, procedures and systems to adjust for the presence of HFT. The CME helped cut off the Flash Crash of 2010 based on its "stop logic" program, which evaluates the ramifications should all of its outstanding orders be executed. Realizing that executing all open orders on that day would have caused a total meltdown, the market shut down. Other exchanges are investigating programs of their own that could help provide stability and help markets function.

Conclusion

Regulation of HFTs and investor opinions about them are both changing rapidly. Where previously there was little public awareness of the impact that these firms have on capital markets, there is now a great deal of scrutiny into their activity and into their relationships with banks and other financial entities. Some of what HFT firms do may be non-beneficial to markets, and to investors seeking to trade within those markets, but regulators and other investigators must be careful to separate the useful functions that HFT firms provide from potentially harmful activities. Activity that helps markets function should be encouraged, while harmful activity should be prevented. Determining what behavior falls into which category will be an ongoing project.

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