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High Frequency Traders: Angels or Devils?

Critics charge that high frequency traders put retail and institutional investors at a disadvantage. They also blame high frequency trading for the US "flash crash" of May 6 2010 and say it has increased the likelihood of such events happening again. A closer examination of these views is in order.

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The Study In Brief

High frequency trading (HFT) is taking world capital markets by storm, notably in the United States and the United Kingdom, where it accounted for about 50 percent of equities trading in 2012, and to a growing extent in other parts of Europe and in Canada.

Are high frequency traders angels or devils in terms of the impact on capital markets? Critics claim the latter and charge that they put retail and institutional investors at a disadvantage. Critics also blame high frequency trading for the "flash crash" on the Dow of May 6 2010 and say it has increased the likelihood of such events happening again. A closer examination of these views is in order.

In this *Commentary*, I first look at what HF traders do and how HFT differs from traditional market making. I then explore the empirical evidence relating to the effect of HFT on capital markets, and canvass the policy issues that HFT raises. In the final section, I list some recommendations for policymakers with respect to HFT.

After surveying empirical studies of HFT, I conclude that it enhances market quality. For example, it lowers bid/ask spreads, reduces volatility, improves short-term price discovery, and creates competitive pressures that reduce broker commissions. Despite being at a pronounced speed disadvantage, retail traders have realized a net gain from the presence of HF traders in the world's capital markets.

Maintain the Order Protection Rule and Contain the Spread of Dark Pools: To prevent abusive trading practices, protect client interests, and create a level playing field among different trading venues, policymakers should defend the consolidated order book by maintaining and policing the order protection rule and minimizing the leakage of trading from the "lit" markets to "dark pools."

Do Not Interfere with Maker/Taker Pricing Models: Some observers say maker/taker pricing raises higher trading costs for retail traders, because retail trade orders are typically on the active side of the market, and associated fees are passed on to customers. However, retail traders are about as likely to be on the active as the passive side of the market. Maker/taker pricing may raise costs on the margin, but also lowers bid/ask spreads.

Focus on Circuit Breakers to Prevent "Flash Crashes": HF traders did not cause the "flash crash," and instead supply liquidity when markets become volatile. Canadian regulators concerned with preventing similar events should focus on circuit breakers to stop market anomalies before they turn into "flash crashes."

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High frequency trading (HFT) – the use of extremely high speed computers and automated trading algorithms to trade high volumes of stock at lightning speed[1] – has transformed world capital markets, nowhere more completely, or more rapidly, than in the United States.

In 2005, HF traders participated in about 30 percent of all US equities trades; by 2009–10 that figure had risen to 60 to 70 percent (see Appendix Table A-1).[2] HFT has gained traction more slowly in European markets, but in 2009–10 still had penetration of 20 to 40 percent. Anecdotal data suggest, however, that HFT in the United States and the United Kingdom converged in 2012, with HF traders participating in about 50 percent of all trades in the two countries (see Brogaard 2010; Golub 2011a; Popper 2012).[3]

HFT has entered Canadian capital markets more slowly. A recent study by the Investment Industry Regulatory Organization of Canada (IIROC), "The HOT Study" (IIROC 2011, 23), suggests that traders with a high order-to-trade ratio (HOT traders) are involved in 37 percent of trades by volume. The study also suggests, however, that not all HOT traders are HF traders and that only 18 percent of the 37 percent is likely to have involved HF traders[4] – in other words, HF traders participated in only 6.6 percent of all trades in the IIROC sample. Another estimate, however, puts the figure at about 40 percent (Cumming et al., 2013).

In this *Commentary*, I first look at what HF traders do and how HFT differs from traditional market making. I then explore the empirical evidence relating to the effect of HFT on capital markets, and canvass the policy issues that HFT raises. In the final section, I list some recommendations for policymakers with respect to HFT.

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1 HF traders do not hold stock or other assets in which they trade for long; the duration of the average round trip – that is, the combined buy/sell or sell/buy transaction – is measured in seconds or milliseconds.

2 The proportion of HF trades as a proportion of all trades is sensitive to the market under scrutiny. HF traders participate, but differentially so, in both "lit" public markets and dark pools. In addition, HF traders such as Getco, ATD, Knight, and Citadel are significant "internalizers," purchasing order flow from retail brokers and internally matching buy-and-sell orders, rather than executing them over a stock exchange or other external trading venue. Although internalization is not technically HFT, it is an important artifact of market structure. In calculating the percentage of trades in which HF traders participate, one should take care to exclude crosses; these are big block trades that are negotiated outside of the lit market and merely reported on a public market.

3 See also "A head start for HFT; or a downward spiral?" *FTSE Global Markets* 66 (November 2012), available online at http://www.ftseglobalmarkets.com/issues/issue-66-november-2012/a-headstart-for-hft-or-a-downward-spiral.html.

4 Those most likely to be HF traders had two particular attributes: they were "fast," and they traded using direct market access; see IIROC (2011, 26).

How HFT Works

The European Commission notes that "HFT is typically not a strategy in itself but the use of very sophisticated technology to implement traditional trading strategies" (European Commission, 14). Gomber et al. (n.d., 1) put it similarly: "HFT is a natural evolution of the securities markets instead of a completely new phenomenon." That is, HFT does not in the main employ novel strategies in pursuit of profit; rather, HF traders pursue familiar strategies – primarily market making and market arbitrage; see Figure 1 – using high-speed computers and sophisticated trading algorithms. Indeed, the main advantage that HF traders have over traditional market makers and arbitrageurs is speed.

Most HF traders are independent of traditional market actors, such as investment banks, and engage in principal, rather than agency, trading. Some HFT, however, is undertaken by the proprietary desks of investment banks and some by hedge funds. According to the TABB Group's Robert Iati, there are between 10 and 20 broker-dealer proprietary desks and fewer than 20 active high-frequency hedge funds. By contrast, there are somewhere between 100 and 300 independent proprietary shops (cited in Golub 2011b). Because of the dominance of the latter category, the growth of HFT has shifted profits away from traditional market actors to the new, independent operators.

What HF Traders Do

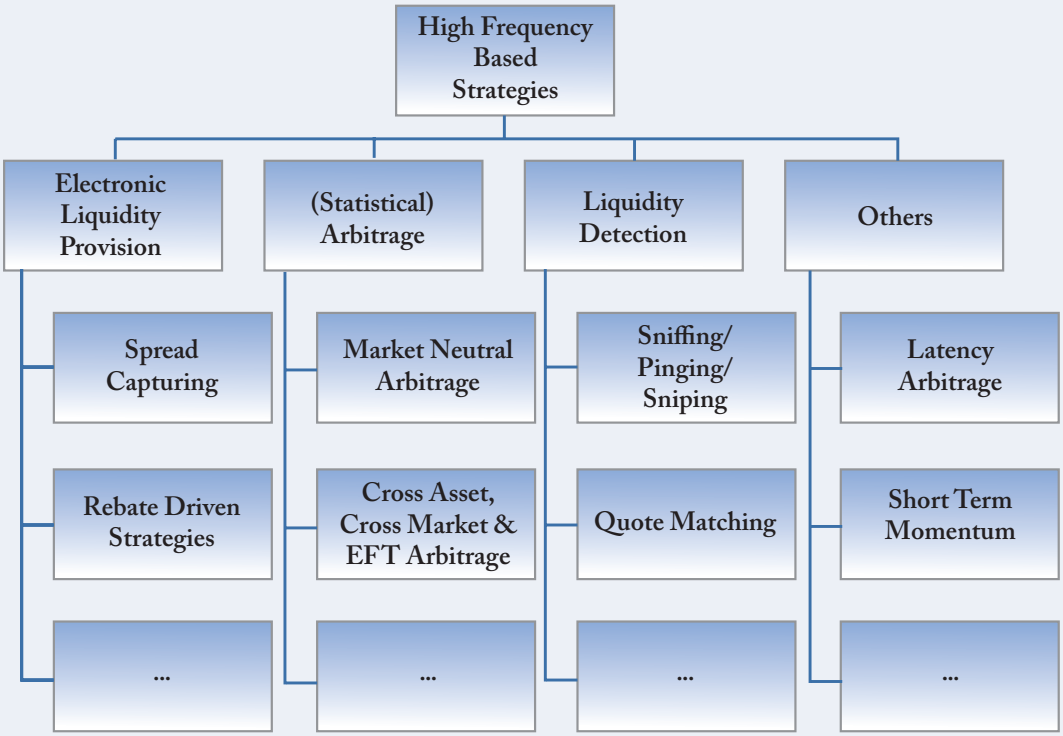
HFT is a subset of algorithmic trading (AT); a useful summary of the common and unique characteristics of AT and HFT is provided by Gomber et al. (n.d.); see Table 1. Both AT and HFT employ computers and trading algorithms to effect trades at high speed without human intervention; however, AT is used mostly by buy-side institutions and hedge funds to reduce the transaction costs of trading large blocks of stock.

The execution of a block trade can induce the price to move unfavourably against the block trader, for at least two reasons. Depending on the depth of book in a given stock, an institutional trader seeking to place a large block might find it necessary to shade its bid or ask price to induce sufficient traders on the other side of the market to trade. In addition, the market might believe that the block trader possesses information that is not reflected in the stock price. If so, the block seller would see the market price fall before it can complete the order, while a block buyer would see the price rise, increasing the cost of executing the trade. To avoid these adverse price movements, many institutional traders disguise their activities by breaking block trades into a number of smaller trades. These are effected over time and at a number of different trading venues if possible; computer-generated algorithms execute these fractionalized trades.

AT traders typically purchase or sell stock based on investment fundamentals. They hold their blocks of stock for days, weeks, or months. Thus, they are often referred to as "directional" or "fundamental" traders, defined as "market participants who are trading to accumulate or reduce a net long or short position. Reasons for fundamental buying and selling include gaining long-term exposure to a market as well as hedging already-existing exposures in related markets" (see United States 2010).

By contrast, although HF traders rigorously assess market demand and supply to determine the likely direction in which prices will move, many are unconcerned with market fundamentals. Instead, their profits arise from earning thin margins on a very large number of small trades. They usually hold stock for no more than a few seconds, and seek to go home "flat" at the end of the day – that is, neither long nor short in any stock. In addition, although AT traders might be either agency or proprietary traders, HF traders are proprietary traders that use their own capital; many, moreover, are non-traditional market actors unaffiliated with incumbent market players.

Figure 1: Strategies Employed by High Frequency Traders



Source: Gomber et al., at 25.

Electronic Liquidity Provision

One of the two principal activities HF traders engage in is market making, which one estimate suggests constitutes 65 to 71 percent of all HFT activity (Hagströmer and Norden 2013).[5] HF traders acting as market makers make money in two ways: by capturing the bid/ask spread in a round-trip transaction, and/or by capturing rebates paid to the "passive" side of a trade.

Spread capturing: Like traditional market makers, many HF traders profit by making a market in a particular stock and capturing the difference between the bid and ask spread on multiple round-trip transactions. Unlike traditional market makers, however, HF traders deal only on fully automated auction markets. Table 2 summarizes some of the more important differences between traditional market makers and HF traders acting as market makers.

5 The abstract states, "We find that market makers constitute the lion's share of HFT trading volume (65–71 percent) and limit order traffic (81–86 percent)."

Table 1: Characteristics of High Frequency Trading and Algorithmic Trading

Common for HFT and AT

1 Pre-designed trading decisions
2 Used by professional traders
3 Observing market data in real-time
4 Automated order submission
5 Automated order management
6 Without human intervention
7 Use of direct market access

Specific for AT excl. HFT

1 Agent trading
2 Minimize market impact (for large orders)
3 Goal is to achieve a particular benchmark
4 Holding periods possibly days/weeks/months
5 Working an order through time and across markets

Specific for HFT

1 Very high number of orders
2 Rapid order cancellation
3 Proprietary trading
4 Profit from buying and selling (as middleman)
5 No significant position at end of day (flat position)
6 Very short holding periods
7 Extracting very low margins per trade
8 Low latency requirement
9 Use of co-location/proximity services and individual data feeds
10 Focus on highly liquid instruments

Source: Gomber et al., 2010, table 2 ("Characteristics of AT and HFT – overview").

(i) Stock selection: Some traditional market makers, such as Designated Market Makers at the New York Stock Exchange (NYSE) or Registered Traders at the Toronto Stock Exchange, contractually agree with the exchange to supply market-making services. In this case, the market maker is required under the rules of the exchange to continuously quote a two-sided market in the stock in respect of which the dealer has agreed to act as market maker (i.e., to post both bid and ask prices at which they are willing to deal), and to honour these quotes at least to a prescribed size (the

Table 2: Comparison of Traditional Market Makers (TMM) and HF Traders Acting as Market Makers

	TMM	HFT
Hyper-speed Trading	✗	✓
Co-location	✗	✓
Proprietary Traders	✓	✓
Designated Market Maker	✓	✗
Incumbent Ownership	✓	✗
Voluntary Market Maker (i.e. spread capturing)	✓	✓
Make Markets in Thinly Traded Stocks	✓	✗
Uses Rebate Capturing as a Business Model	✗	✓
Target Inventory	Positive (sufficient to honour ask quote against anticipated purchase order flow)	0 (flat at end of day)
Orders Per Trade	Low	High
Ratio of Adverse Selection Component of Bid/Ask Spread to Transaction Cost Component	High	Low (extremely fast trading minimizes price risk)
Volatility Preference	✗	✓
Margin Per Trade	High	Low
Volume of Trades	Low	High

Source: Author's compilation.

minimum guaranteed fill). HF traders, however, pick and choose which stocks they will deal in, and are under no obligation to continuously make a market or to honour a minimum guaranteed fill.[6] HF traders rely on a high volume of thin-margin order flow to generate profits, and to this end they actively seek to identify stocks in which there is a depth of book. For this reason, HF traders trade mostly large, well-capitalized issuers whose securities trade in liquid markets.

(ii) Target inventory: The target inventory for HF traders is zero. They may depart temporarily from this condition during the course of a trading day, but they almost always ensure that they are

6 The IIROC HOT Study finds that HF traders trade mainly in common shares and exchange-traded funds and notes (IIROC 2011, 31). Although HF traders are under no obligation to make a market, they do not receive a number of advantages usually conferred on traditional market makers, such as fee remissions and exemptions from short sales rules.

"flat" at the end of the day, thus avoiding any overnight price risk. By contrast, traditional market makers typically maintain a target inventory (see, for example, Stoll 1978). Dealers acting as market makers set a two-sided market, and seek to ensure they have sufficient securities on hand to meet expeditiously the demand of those who wish to purchase securities in which they are making a market. Although a market maker may hold no inventory at all and still satisfy customer demand for sales by selling short and then repurchasing the securities in the market, there is evidence that traditional market makers that hold long positions make greater profits than dealers that go short to satisfy customer demand. The difference is both statistically and economically significant (Hendershott and Seaholes 2007; see also Comerton-Forde et al. 2010).

(iii) Technological sophistication and speed of trading: Like HF traders, traditional market makers are heterogeneous, but most lack the sophisticated computer hardware and software that HF traders use to drive their trading strategies and their actual trading.[7] HFT, on the other hand, is "a highly quantitative tool that employs algorithms along the whole investment chain: analysis of market data, deployment of appropriate trading strategies, minimisation of trading costs and execution of trades" (IOSCO 2011, 22). Speed is essential to HFT activities in order to manage risk.[8] To this end, HF traders rely on highly sophisticated hardware and software (and co-location, as discussed below) to reduce message "latency"[9] to a small fraction of a second.

Speed is vital in both market making and arbitrage activities. A market maker seeks to effect a round-trip transaction in as little time as possible. This minimizes the risk that the price will move against the market maker before it can effect the second leg of the round-trip transaction. The speed HF traders use is a natural outgrowth of the drive to effect round-trip transactions as quickly as possible. In addition, HF traders acting as market makers compete with other HF traders for order flow: traders that are able to post their orders faster than the competition, even if by only milliseconds or microseconds, are able to scoop active order flow.[10] When HF traders act as arbitrageurs, speed is just as important. Particularly as there are many HF traders constantly searching for arbitrage opportunities, these are rarely open for more than a few fractions of a second. Just as with market making, being the first in line means being able to exploit these fleeting instances of market mispricing.

(iv) Volume and margins: HF traders are high-volume, low-margin traders, executing a large number of trades at small (or even zero) spreads. This contrasts with traditional market makers, which historically have executed a relatively small number of trades at relatively high margins.

7 This is not to say that there are no designated market makers that do not employ a high degree of sophistication in their trading activities (see Gomber et al., n.d.), but the high-tech computer game is dominated by HFT.

8 The IIROC HOT Study (IIROC 2011) classifies 32 percent of its HOT sample as "fast," 12 percent as "slow," and 56 percent as "inconclusive." However, the fast traders that are most likely to be HF traders (those with direct market access) accounted for 84 percent of trading by volume, 87 percent by value, and 90 percent by number of trades.

9 There does not seem to be a standard definition of latency in the literature. However, a common definition is the amount of time it takes for an investor to submit and receive feedback about an order. See, for example, Riordan and Storkenmaier (2011, 2).

10 This, of course depends on the existence of trade-through rules that confer an advantage on price-time priority. There are no such rules in Europe, which likely accounts for the lower degree of HF trader penetration there.

(v) The order-to-trade ratio: HFT trading is also characterized by a high order-to-trade ratio (see IIROC 2011). The subset of HOT traders that is more likely to be HF traders (those with direct market access) had an average order-to-trade ratio of 46 (IIROC 2011, 22).[11] There are a number of reasons for this high ratio. First, HF traders use what might be characterized as "scout" orders that are designed to sniff out liquidity and depth of book at different trading venues. These orders are quickly cancelled if they do not result in a trade within a very short period of time (often a fraction of a second). Second, the longer a limit order is left on the books of a trading venue, the greater the price risk (the likelihood that the price of the stock will move in a direction uncongenial to the HF trader). Limit orders of very short duration minimize this price risk and allow HF traders to reassess the situation and possibly to re-price and re-submit.[12]

Rebate-driven strategies: It has become common in the past 5 or 10 years for trading venues to employ a "maker/taker" model of pricing. Traders who post limit orders – so-called passive traders – are paid a rebate if the order ultimately results in a trade. Traders who post market orders or marketable limit orders that are immediately executed against standing limit orders are called "active traders." These traders are charged a fee, and as the fee they pay is higher than the rebate paid to the passive trader, the trading venue collects the difference between the two.[13] In the absence of maker/taker pricing, HF traders derive revenue only from buying low and selling high. Maker/taker pricing, however, allows HF traders to buy and sell at exactly the same price and to derive revenue entirely from the rebates paid on passive orders posted to the exchange.

The effect of rebate trading is thus to induce HF traders to line the books of one or more trading venues with large numbers of passive orders. Although HFT tends to narrow bid/ask spreads even in the absence of rebate trading, the effect of rebate trading is to narrow the spread even further. Rebate trading thus results in improved liquidity for other traders (as empirical evidence described below confirms).

Statistical Arbitrage

Traditional actors have long-since engaged in various forms of market arbitrage in pursuit of profit. As is generally true with HFT, HF traders have borrowed these time-tested trading strategies. However, they are able to detect and exploit market pricing inefficiencies much faster than traditional actors. For this reason, instances of anomalous cross-market or cross-asset pricing often last for only a small fraction of a second. HF traders predominantly engage in two forms of arbitrage: market-neutral arbitrage, and cross-asset, cross-market, and exchange-traded fund arbitrage (see Gomber et al. n.d., 27).

11 As figure 14 of the HOT Study and accompanying text make clear, however, not all HOT traders with direct market access are likely to be HF traders; only those that are also "fast." As HF traders are highly heterogeneous in their trading strategies (if not in their degree of sophistication), it would be both interesting and useful to know the median as well as the mean order-to-trade ratio.

12 As pointed out to the author by Ian Bandeen, the most successful HF traders are not necessarily those with the highest order-to-trade ratio. HF traders profit only when they trade. When an order is cancelled and re-submitted, the trader goes to the bottom of the price/time priority queue. While, as always, HFT strategies are heterogeneous, many relatively sophisticated and profitable HF traders have comparatively low order-to-trade ratios.

13 Some trading venues employ reverse maker/taker pricing, in which the passive trader is charged a fee and the active trader is paid a rebate. There is currently a great deal of experimentation in pricing models by different trading venues.

Market-neutral arbitrage: A dealer engages in market-neutral arbitrage by going long in an asset it believes to be undervalued, while simultaneously short selling an asset it believes to be overvalued. If the market volatilities of the assets are similar, an increase in the market will cause the long asset to appreciate in value and the short asset to depreciate by a roughly offsetting amount. Conversely, if the market falls, the short and long assets will respectively increase and decrease in value, again in offsetting amounts. The dealer is thus protected against movements in the market while holding the two assets. The dealer will sell the assets when they "normalize" to their fundamental values, earning the difference between the purchase prices of the assets and these normalized values.

Cross-market, cross-asset, and exchange-traded fund arbitrage: Cross-market arbitrage seeks to take advantage of different prices of the same asset in different markets. This is done by purchasing an asset in the lower-valuing market, and selling it in the more highly valuing market.

Cross-asset arbitrage works in a similar way. Two early forms of such arbitrage engaged in by HF traders (again, following in the footsteps of traditional market actors) are foreign exchange and index arbitrage. In the former, the trader identifies and exploits inconsistencies in the relative prices of a bundle of currencies. In the latter, the trader identifies what it believes to be an inconsistency between a stock index future and the current value of the index. It will then buy (or sell) a futures contract on the stock index while simultaneously selling (or buying) the stocks that underlie the index.

Exchange-traded fund arbitrage is simply a form of cross-asset arbitrage. It is effected by identifying discrepancies between the quoted value of an exchange-traded fund and its underlying assets. Where such a discrepancy occurs, the dealer will go long in the comparatively undervalued asset, and short the overvalued asset.

HFT arbitrage versus traditional arbitrage: In both cases discussed above, HFT is a natural outgrowth of traditional arbitrage activity. Both market neutral and cross-asset, cross-market, and exchange-traded fund arbitrage are not so much novel means of earning a profit as novel mechanisms for effecting a familiar profit-making strategy, using the power of high-speed computers and sophisticated trading algorithms.

Liquidity Detection

HF traders send out what might be characterized as "scout orders" to discovery where liquidity may be found. These scout orders attempt to gather information about the order book at different trading venues,[14] with a particular emphasis on detecting

14 The Australian Securities and Investments Commission (Australia 2010, 48) describes liquidity detection in the following manner:

This strategy seeks to decipher whether there are large orders existing in a matching engine by sending out small orders, or "pinging," to look for where large orders might be resting. Some liquidity detection strategies are described as 'predatory' in nature. These include:

- *pinging* – sending out large numbers of small orders with the intention of getting a fill or to gain information about electronic limit order books;
- *sniper* – an algorithm that tries to detect "hidden" liquidity by trading in round or odd lots until it completes or reaches an investor's limit price; and
- *sniffing* – used to "sniff out" algorithmic trading and the algorithms being used by sending a small portion of an order and waiting to see if it is hit. Sniffers attempt to outsmart many buy-side algorithmic techniques, such as iceberging.

large orders such as iceberg orders,[15] sliced orders,[16] or orders executed by trading algorithms. This knowledge is then used strategically to place orders on the opposite side of the market – although critics claim that such liquidity detection is used to "front run" institutional orders by placing orders on the same side of the market.

Quote Matching

Some HF traders allegedly use a strategy known as "quote matching," which is essentially a form of front-running. However, unlike conventional front-running, it is not illegal, since the information upon which it is based does not derive from direct knowledge of another entity's trading activity, but from guesswork. Lycancapital poses the following example.[17] Suppose that an HF trader's scout orders suggest that a buy-side institution has placed a large purchase limit order at $30. The HF trader will then post a purchase limit order either at $30 at an alternative trading venue where it can secure price/time priority, or just slightly above $30 at the same trading venue as the institution. If the HF trader's limit order fills and the block trading activity drives up the price of the stock, the HF trader will then sell the stock for a profit. If the price should fall, however, the HF trader can use its speed advantage to enter a $30 sell order before the institution has cancelled its $30 purchase limit order, and sell stock to the institution with a minimal or no loss.

Like any form of front-running, quote matching increases the cost of trading for patient traders posting large orders (such as buy-side institutions and hedge funds). Posting matching orders on the same side of the market causes the price to move against the block trader. In addition, the nimble HF trader effectively uses the block trader's order as an option for the purpose of limiting its own loses, should the market move in an unfavourable direction.

As discussed below, however, Canadian trading rules seem to render quote-matching difficult or impossible in Canadian markets.

Latency Arbitrage and Co-location

As noted, HF traders prosper by being faster than their competitors. One strategy to achieve the lowest possible latency is "co-location," in which the HF trader rents server space in the same building in which the trading venue's matching computer is located. This reduces the time that it takes for electronic messages to travel to and from the trading venue. As electronic signals move at or near the speed of light (depending on the medium of transmission),[18] the advantage of co-location is not immediately obvious to the lay observer. However, a signal transmitted via optical cables takes about 5.5 microseconds to travel one kilometre. Moving the HF trader's servers 100 kilometres closer to the trading venue thus increases the one-way signal speed by some 550 microseconds, and the two-way speed – that is, the message and reply – by a little more than one millisecond. Indeed, the advantage of co-location can be far greater. On the 4,000-kilometre-wide North American continent, a west coast HF trader that co-locates its servers at

15 A trader who places an iceberg order allows only the tip of the order to be visible to the market. If the tip is traded, then other orders automatically jump into the order book.

16 As noted earlier, many institutional traders will slice a large trade into smaller bits in order to conceal the block trade from the market.

17 This example is taken from lycancapital, "Equity Trading in the 21st Century," Part 4.3.2. (p. 30), available for purchase at http://www.scribd.com/doc/55149533/EquityTradinginthe21stCentury.

18 Satellite signals move at the speed of light, requiring 3.3 microseconds to traverse one kilometre. Signals carried by optical cable or copper wire travel slightly slower, requiring (respectively) 5.5 and 5.6 microseconds to traverse one kilometre.

the NYSE can reduce its two-way system latency by about 44 milliseconds – a virtual eternity in the modern world of high-speed trading (see Schmerken 2009).[19] But even this understates the advantage of co-location. The IIROC HOT Study (2011) found that, on average, HF traders (those with direct market access) had an order-to-trade ratio of 46 to 1.[20] Thus, a single trade depends on a volley of rapid-fire message traffic between the HF trader and the trading venue. The number of messages required to produce a single trade greatly amplifies the advantage of co-location.[21]

Short-term Momentum Strategies

Momentum traders seek to predict the manner in which the market for individual stocks will move over a short time frame. They employ increasingly sophisticated methods to this end, such as linguistic computer programs that scan media reports, blogs, and even Twitter accounts, seeking out key words or concentrations of activity. As Gomber et al. (n.d., 30) state:

> Market participants leveraging HFT technologies to conduct short-term momentum strategies are a modern equivalent to classical day traders. In contrast to many other HFT based strategies they are neither focused on providing the market with liquidity, nor are they targeting market inefficiencies. They usually trade aggressively (taking liquidity) and aim at earning profits from market movements/trends. Their trading decisions can be based on events influencing securities markets and/or the movements of the markets themselves. Momentum based trading strategies are not new and have been implemented by traditional traders for a long time.

HFT and Market Microstructure: Issues

The newfound presence of HF traders in the world's capital markets has created a lively public debate, with spirited advocates trading barbs with equally spirited detractors, the latter suggesting that the presence of HFT has led to a loss of retail investor confidence in securities markets. Critics also charge that HF traders routinely engage in quote-matching, front-running institutional orders and generating illicit profits while increasing institutional execution costs (see Brown 2010). More generally, critics contend that HF traders interfere with the process of price discovery, exacerbate volatility, supply only illusory liquidity that lacks depth of book, and increase market manipulation. Critics also assert that the US "flash crash" of May 6, 2010 was either caused or exacerbated by HFT. Supporters of HFT not only deny all of these claims, but vigorously assert precisely the opposite: that HFT has lowered bid/ask spreads, enhanced price discovery, lowered volatility, and created greater liquidity. They also assert that the presence of HFT has benefited both retail and institutional traders.

At bottom, what is at stake is the issue of allocative efficiency in the real economy, the sector of the economy in which goods and services are produced. Allocative efficiency in the real economy

19 These figures are not merely theoretical. When Hyde Park Global relocated its servers from Atlanta to New York, it shaved 21 milliseconds off its trades (Golub 2011b).

20 Most HFT orders are scout orders that are never executed. However, these convey important information to the HF trader about bid/ask prices and the depth of liquidity in various trading venues, as well as about order imbalances that might affect the direction in which the price will move.

21 Many trading facilities, such as the NYSE, now ensure that all co-located tenants have precisely equal cable lengths, so that some players do not have an advantage over others. Other facilities charge different prices for different cable lengths, and small differences in cable lengths can result in large differentials in pricing.

can be achieved only if allocative efficiency is also achieved in capital markets. The issues canvassed above – such as the effect of HFT on bid/ask spreads, volatility, and price discovery – are of fundamental importance to achieving both types of efficiency.

Allocative Efficiency in the Real Economy and Capital Markets

Allocative efficiency in the real economy (AER) is achieved when the money of net savers of capital is funnelled to net users of capital offering the "best" uses of capital. In financial economics, "best" means those projects that offer the best risk/expected return tradeoff, as seen through the lens of a model of asset returns such as the capital-asset-pricing model or arbitrage-pricing theory. Capital markets serve as a bridge between net savers and net users of capital. For this reason, AER cannot be achieved without allocative efficiency in capital markets.

The primary market supplies the most obvious case. There, issuers seek to sell financial claims directly to investors. The issuers are net users of capital, while the investors are net savers or intermediaries holding the funds of net savers. Although not all primary market issuers use newly raised funds in the real economy (mutual funds, for example, do not), many do; thus, AER requires that the primary market be efficient. That is, funds available for investment should be placed with those primary market offerings exhibiting the best tradeoff between risk and expected return. If this condition does not hold, then capital is misallocated and AER is not achieved.

And what of the secondary markets? Secondary market efficiency is a condition for achieving primary market efficiency. For one thing, primary market offerings are priced off the secondary market price. Thus, mispricing in the secondary market will result in mispricing in the primary market. In addition, secondary market liquidity is a priced attribute of securities – that is, *ceteris paribus*, investors will pay more for securities that trade in liquid markets (see Amihud, Mendelson, and Pedersen 2005). The following section explores some of the more important determinants of secondary market liquidity.

Liquidity and Secondary Market Efficiency

Secondary market liquidity is dependent on a number of factors, among the most important of which are immediacy, bid/ask spreads, transaction costs, volatility, and depth of market.[22]

Immediacy describes a situation in which buyers and sellers are able to locate a party with whom to trade without significant delay. Immediacy is a necessary, but not a sufficient, condition for liquidity. Consider an example involving a thinly traded security – that is, one in which few buyers or sellers are present in the market at any given time. In such a market, market makers are likely to quote wide bid/ask spreads. For example, the best bid might be $1.00 per share and the best ask $2.00 per share. Even with this wide bid/ask spread, a buyer could secure immediacy by crossing the spread and purchasing shares at $2.00. But this would be a heavy price to pay. Should that buyer immediately decide to sell the same shares, immediacy again

22 A variety of factors ultimately come into play in defining liquidity. Amihud, Mendelson, and Pedersen (2005, 270 state that "liquidity is the ease of trading a security." The authors identify a number of factors that potentially impair liquidity, including "exogenous transaction costs" (for example, brokerage fees and order-processing costs), "demand pressure" (the fact that not all buyers and sellers are present in the market at a given time), "inventory risk," "private information," and "search friction" (the cost of locating a counterparty or counterparties willing to trade, an issue of particular importance for block traders).

could be achieved, but once again only by crossing the bid/ask spread and selling at $1.00. Thus, even if quoted market prices had not changed in the slightest, the buyer-turned-seller would have incurred a loss of $1.00 per share on the round-trip transaction. In short, liquidity describes a condition in which immediacy can be secured with modest bid/ask spreads.

Transaction costs are another important attribute of liquidity. Suppose, for example, that a broker were to charge her client $1.00 per share in order to purchase or sell a share trading in the range of $1.00. In order to recoup her investment, net of transaction costs, the purchaser would have to see the price rise to $3.00 just to break even on a round-trip transaction (i.e., a buy followed by a sell). With such high transaction costs, few people would be willing to trade in low-priced stocks. An efficient secondary market is thus one in which transaction costs are trivial relative to the prospective gains from trading.

Volatility and Secondary Market Efficiency

Volatility is a form of transaction cost. The greater the volatility, the greater is the likelihood that the market will move adversely after a limit or market order is submitted. This risk causes market makers to widen their bid/ask spreads, increasing the cost of trading for both institutional and retail traders (see Harris 2003, chap. 14).

The Structure of the Financial Services Industry and Secondary Market Efficiency

Another factor that has an impact on the achievement of allocative efficiency in the capital markets (and derivatively in the real economy) is the structure of the financial services industry. A more competitive industry lowers bid/ask spreads and transaction costs, and increases liquidity, to the benefit of all traders.

HFT Empirics: Are HFTs Good or Bad for Capital Markets?

Some of the empirical studies on HFT are summarized in Table 3. One caveat must be made, however, in interpreting this evidence. Some of these studies test the effect of all algorithmic trading on capital markets. Unfortunately, this approach lumps together two rather disparate forms of activity: trading conducted by institutional block traders seeking to avoid market effects, and trading conducted by HF market makers and arbitrageurs. Thus, a finding of statistical significance might result from one activity and not the other. Alternatively, a finding of non-significance might be the result of the differential impact of the two forms of trading. For this reason, care should be taken when interpreting the results of studies that pool all forms of algorithmic trading.

Despite this caveat, the evidence digested in Table 3 suggests that HFT has improved market quality. As noted above, a principal activity of HF traders is to act as market makers. Many studies suggest that, in this role, the presence of HFT has reduced bid/ask spreads substantially and that, in a majority of cases, HF traders offer the inside quote.[23] This evidence does not support the criticism that HFT liquidity is "fleeting" or "illusory."[24]

23 See Brogaard (2010); Hasbrouck and Saar (2010); Jarnecic and Snape (2010); Jovanovic and Menkveld (2010); Groth (2011); Hendershott, Jones, and Menkveld (2011); and Malinova, Park, and Riordan (2012).

24 This view draws inspiration from the fact that HFT has a very high order-to-trade ratio, and many more orders are cancelled than those that result in trades. However, focusing on the order-to-trade ratio is not informative. It is not the number of cancelled orders that is of importance to other traders, but the very high number of HFT quotes that are executed against.

Table 3: Empirical Studies on Impact of HFT on Capital Markets – Major Findings

	IIROC	Malinova, Park, and Riordan (2013)[1]	Jarnecic and Snape (2010)[2]	Riordan and Storken-maier (2011)[3]	Brogaard (2010)[4]	Björn Hagströmer & Lars Nordén (2013)[5]	Kearns, Kulesza, and Nevmyvaka (2010)[6]	Hasbrouck and Saar (2013)[7]	Hendershott and Riordan (2009)[8]	Brogaard, Hender-shott, and Riordan (2013)[9]	Chaboud, Chiquoine, Hjalmarsson, and Vega (2009)[10]	Kirelenko, Kyle, Samadi, and Tuzun (2011)[11]	Hendershott, Jones, and Menkveld (2011)[12]	Menkveld (2013)[13]	Jovanovic and Menkveld (2012)[14]	Groth (2011)[15]	Baron, Brogaard, and Kirilenko (2012)[16]	Golub, Keane, and Ser-Huang Poon (2012)[17]	Cumming et al. (2013)[18]
Where are HFT Found?		-tend to concen-trate in TSX60 stocks	-large cap stocks-high price volatility -markets with low tick size -markets lacking in-formed trading		-more volatile stocks (but effect only moder-ate)														

1 Katya Malinova, Andreas Park, and Ryan Riordan, "Do retail traders suffer from high frequency traders?" Working Paper, May, 2013, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2183806.

2 Elvis Jarnecic and Mark Snape, "An analysis of trades by high frequency participants on the London Stock Exchange", *17th Annual Conference of the Multinational Finance Society MFS 2010*, Barcelona, Spain, 30th June 2010.

3 Ryan Riordan and Andreas Storkenmaier, "Latency, Liquidity, and Price Discovery", Working Paper, November, 2011 (forthcoming, *Journal of Financial Markets*), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1247482.

4 Jonathan Brogaard, "High Frequency Trading and its Impact on Market Quality", Working Paper, July 2010, available at http://www.futuresindustry.org/ptg/downloads/HFT_Trading.pdf.

5 Björn Hagströmer and Lars L. Norden, "The Diversity of High-Frequency Traders", Working Paper, May 2013, available at SSRN: http://ssrn.com/abstract=2153272.

6 Michael Kearns, Alex Kulesza, and Yuriy Nevmyvaka, "Empirical Limitations on High Frequency Trading Profitability" (2010) 50 *Journal of Trading* 50.

7 Joel Hasbrouck and Gideon Saar, "Low-Latency Trading", Working Paper, May 2013, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1695460.

8 Terrence Hendershott and Ryan Riordan, "Algorithmic Trading and Information", Working Paper, July 2009, available at http://www.im.uni-karlsruhe.de/Upload/Publications/218bfa37-798e-44df-8ad3-8289af8a0920.pdf.

9 Jonathan Brogaard, Terrence Hendershott, and Ryan Riordan, "High Frequency Trading and Price Discovery", Working Paper, April 2013, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1928510.

10 Alain Chaboud, Benjamin Chiquoine, Erik Hjalmarsson, and Clara Vega, "Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market", Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 980, October, 2009, available at http://ssrn.com/paper=1501135 (forthcoming, *Journal of Finance*).

11 Andrei Kirilenko, Albert S. Kyle, Mehrdad Samadi, and Tughan Tuzun, "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market", Working Paper, May 2011, available at http://papers.ssrn.com/sol3/papers. cfm?abstract_id=1686004.

12 Terrence Hendershott, Charles M. Jones, and Albert J. Menkveld, "Does Algorithmic Trading Improve Liquidity?" (2011), 66 J. Fin. 1.

13 Albert J. Menkveld, "High Frequency Trading and the New Market Makers", Working Paper, May 2013, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1722924.

14 Boyan Jovanovic and Albert J. Menkveld, "Middlemen in Limit Order Markets", Working Paper, November 2012, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1624329.

15 Sven Groth, "Does Algorithmic Trading Increase Volatility? Empirical Evidence from the Fully-Electronic Trading Platform Xetra", 2011, forthcoming proceedings of the 10th International Conference on Wirtschaftsinformatik, Zurich, available at http://www.futuresindustry.org/ptg/downloads/WorkingPaper_Algo_SvenGroth.pdf.

16 Matthew Baron, Jonathan Brogaard, and Andrei Kirilenko, "The Trading Profits of High Frequency Traders", Working Paper, August 2012, available at http://www.bankofcanada.ca/wp-content/uploads/2012/11/Brogaard-Jonathan.pdf.

17 Anton Golub, John Keane, and Ser-Huang Poon, "High Frequency Trading and Mini Flash Crashes", Working Paper, November 2012, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2182097

18 "Douglas Cumming, Feng Zhan, and Michael Aitken, "High Frequency Trading and End-of-Day Manipulation" Schulich School of Business Working Paper, Sept. 2013, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2145565.

Table 3: Continued

	IIROC	Malinova, Park, and Riordan (2013)	Jarnecic and Snape (2010)	Riordan and Storkenmaier (2011)	Brogaard (2010)	Björn Hagströmer & Lars Nordén (2013)	Kearns, Kulesza, and Nevmyvaka (2010)	Hasbrouck and Saar (2013)	Hendershott and Riordan (2009)	Brogaard, Hender-shott, and Riordan (2013)	Chaboud, Chiquoine, Hjalmarsson, and Vega (2009)	Kirelenko, Kyle, Samadi, and Tuzun (2011)	Hendershott, Jones, and Menkveld (2011)	Menkveld (2013)	Jovanovic and Menkveld (2012)	Groth (2011)	Baron, Brogaard, and Kirilenko (2012)	Golub, Keane, and Ser-Huang Poon (2012)	Cumming et al. (2013)
Impor-tance of Latency				-reduction in trading venue latency re-duces adverse selection component of bid/ask spread and results in reductions in quoted bid/ask spreads -latency reduction improves the contribution of quotes to price discov-ery, making prices more efficient													-fastest firms earn the highest profits -main source of profits is "Oppor-tunistic Traders"[19] -how-ever, "Small traders" lose the most on a per contract basis[20] -loss only 0.0007%		

19 The authors state that Opportunistic Traders are "likely brokerage firms, hedgers, hedge funds, small institutional investors, "and other hard to identify traders."

20 Small traders lose "$3.49 to Aggressive HFTs compared to $1.92 for Fundamental traders and $2.49 for Opportunistic traders, for a contract valued at approximately $50,000."

Table 3: Continued

	IIROC	Malinova, Park, and Riordan (2013)	Jarnecic and Snape (2010)	Riordan and Storkenmaier (2011)	Brogaard (2010)	Björn Hagströmer & Lars Nordén (2013)	Kearns, Kulesza, and Nevmyvaka (2010)	Hasbrouck and Saar (2013)	Hendershott and Riordan (2009)	Brogaard, Hender-shott, and Riordan (2013)	Chaboud, Chiquoine, Hjalmarsson, and Vega (2009)	Kirelenko, Kyle, Samadi, and Tuzun (2011)	Hendershott, Jones, and Menkveld (2011)	Menkveld (2013)	Jovanovic and Menkveld (2012)	Groth (2011)	Baron, Brogaard, and Kirilenko (2012)	Golub, Keane, and Ser-Huang Poon (2012)	Cumming et al. (2013)
Effect on Liquidity		-HFT signifi-cantly lower spreads -HFT reduce trad-ing costs for non-HFT traders (espe-cially retail), despite dis-placement to market orders -less liquid stocks most affected by increas-ing cost of HFT trading	-smooth out liquidity		-provide inside quotes 50% of time			-improve liquidity					-AT/HFT narrow spreads	-sub-stantially lowered bid/ask spread	-29% reduction in bid/ask spread				
Makers or Takers?	-passive 66%, active 31% -other traders passive 37%, active 48%[21]				-HFT consume liquidity when it is cheap and provide it when it is expensive -taker for 50.4% of all trades -maker for 51.4% of all trades	-act as market makers 65-71% of time			-AT/HFT consume liquidity when it is cheap and provide it when it is expensive					-HFT 80% pas-sive					

21 The remaining percentages are classified as "NA".

Table 3: Continued

	IIROC	Malinova, Park, and Riordan (2013)	Jarnecic and Snape (2010)	Riordan and Storken-maier (2011)	Brogaard (2010)	Björn Hag-strömer & Lars Nordén (2013)	Kearns, Kulesza, and Nevmyvaka (2010)	Hasbrouck and Saar (2013)	Hendershott and Riordan (2009)	Brogaard, Hendershott, and Riordan (2013)	Chaboud, Chiquoine, Hjalmarsson, and Vega (2009)	Kirelenko, Kyle, Samadi, and Tuzun (2011)	Hendershott, Jones, and Menkveld (2011)	Menkveld (2013)	Jovanovic and Menkveld (2012)	Groth (2011)	Baron, Brogaard, and Kirilenko (2012)	Golub, Keane, and Ser-Huang Poon (2012)	Cumming et al. (2013)
Price Discovery					-HFT add substan-tially to price discovery -HFT quotes contribute more to price discovery than non-HFT quotes					-HFT improve price discovery -tend to trade in direction of permanent price changes and against transitory price changes -incorporate public infor-mation and limit order imbalances in trades -however, time horizon short (3-4 seconds)			-AT/HFT enhances informativeness of both quotes and trading prices						
Effect on Institu-tional Traders										-reduce institutional trading costs by reducing temporary price pressure									
Do HF Traders Ma-nipulate Securities Markets?																			-a significant pres-ence of HF traders lowers the likelihood of end-of-day price manipulation by 70.6%, and has a greater effect in this regard than either trading rules or surveillance and enforcement efforts.

Table 3: Continued

	IIROC	Malinova, Park, and Riordan (2013)	Jarnecic and Snape (2010)	Riordan and Storkenmaier (2011)	Brogaard (2010)	Björn Hagströmer & Lars Nordén (2013)	Kearns, Kulesza, and Nevmyvaka (2010)	Hasbrouck and Saar (2013)	Hendershott and Riordan (2009)	Brogaard, Hender-shott, and Riordan (2013)	Chaboud, Chiquoine, Hjalmarsson, and Vega (2009)	Kirelenko, Kyle, Samadi, and Tuzun (2011)	Hendershott, Jones, and Menkveld (2011)	Menkveld (2013)	Jovanovic and Menkveld (2012)	Groth (2011)	Baron, Brogaard, and Kirilenko (2012)	Golub, Keane, and Ser-Huang Poon (2012)	Cumming et al. (2013)
Effect on Market Volatility			-un-likely to increase volatility		-sig-nificantly reduce intraday volatility -tend to be contrarian traders			-dampen short-term volatility			-no causal relationship between AT/ HFT and mar-ket volatility					-AT/ HFT do not sig-nificantly increase volatility -"actu-ally, the opposite seems to be true"			
Flash Crash					-HFT do not with-draw from markets in bad times					-HFT continue to provide liquid-ity when markets are under stress or highly volatile		-did not cause Flash Crash, but shifted from liquidity suppliers to liquidity demanders, exacerbat-ing market volatility				-AT/ HFT do not withdraw from the market during periods of high volatility		-68% of mini-flash crases were initiated by intermarket sweep orders	
Front-running Non-HFT Orders					-no														
HFT Profits					-26 HFT firms in sample earned $3 billion/ year		-upper bound on HFT profits of $3.4 billion/ year (which the authors regard as an overestima-tion)												
Effect on Com-petition Between Trading Venues														-a single HFT entrant a key factor in growth of Chi-X market in Europe					

HFT has also reduced intraday volatility.[25] HF traders tend to smooth prices by trading against transitory price changes and in the direction of permanent price changes. They have also improved price discovery, albeit over a short time frame (see Brogaard 2010; Brogaard, Hendershott, and Riordan 2013; and Hendershott, Jones, and Menkveld 2011). HFT thus impounds new fundamental information into stock prices more quickly and corrects limit order imbalances.

While there is as get relatively little evidence concerning market manipulation by HF traders, a study by Cumming et al. found that significant representation of HF traders in a given market actually lowers the likelihood of end-of-day price manipulation by 70.6 percent (a figure which is robustly statistically significant) (Cumming et al. 2013). The authors found that the presence of HF traders had a greater effect in this regard than did either trading rules or surveillance and enforcement efforts.

HF traders are found on both the "maker" and the "taker" side of the market. HF traders acting as market makers trade passively, offering immediacy to other traders (see IIROC 2011; Hagströmer and Norden 2013; and Menkveld 2013). HF traders acting as arbitrageurs trade actively, consuming liquidity (i.e. they take the active side of the trade). In addition, HF traders consume liquidity when it is cheap (that is, when bid/ask spreads are tight), and offer it when it is expensive (that is, when bid/ask spreads are relatively wide) (Hendershott and Riordan 2009; Brogaard 2010). A qualification to the empirical evidence is that HF traders tend to play only in relatively large cap stocks with deep markets (Malinova, Park, and Riordan 2013). They also tend to shy away from markets with high tick sizes and a significant degree of informed trading (Jarnecic and Snape 2010).

HFT has also affected market structure. The rise of alternative trading platforms has gone hand-in-hand with the rise of HF traders, as many traditional stock exchanges were either slow to respond to the technological needs of HF traders or actively hostile to their presence. Alternative trading venues have capitalized on these shortcomings by building HFT-friendly platforms and scooping large volumes of trading from the traditional incumbents. The enhanced competition between trading platforms has greatly reduced brokerage costs.

The empirical evidence thus strongly suggests that HF traders have improved market quality.

Does HFT Disadvantage Retail or Institutional Traders?

The view that HFT has adversely affected retail traders is based on the observation that the latter cannot possibly compete on speed with HF traders, whether submitting market or limit orders. Nonetheless, overall, there is a compelling argument that HFT has improved the lot of retail traders, for several reasons. First, as noted above, HFT has greatly improved market quality, narrowing bid/ask spreads, reducing intraday volatility, and supplying competitive pressure that has helped to reduce retail brokerage fees. All of this has redounded to the benefit of retail traders.

Second, it is important to remember that the question is not whether retail traders are at an absolute disadvantage when compared to HF traders, but the extent of the marginal disadvantage created by the appearance of HF traders. Retail traders tend to be uninformed traders, and uninformed traders have always fared poorly in markets in which there are better informed traders, whether these are buy-side institutions, hedge funds, or market makers, and whether the uninformed traders post limit or market orders (see Barber, Odean, and Zhu 2009, 303). Thus, it is not

25 See Chaboud et al. (2009); Brogaard (2010); Hasbrouck and Saar (2013); Jarnecic and Snape (2010); and Groth (2011).

immediately obvious that the additional trading speed that HF traders exhibit has put retail traders at a materially greater disadvantage than that which already existed vis-à-vis traditional market players.

Third, even the absolute disadvantage of retail traders vis-à-vis HF traders is small relative to gains that retail traders have realized from the presence of HF traders, such as reductions in bid/ask spreads and brokerage commissions. Thus, while Baron, Brogaard, and Kirilenko (2012) find that retail traders lose more per contract to HF traders than any other type of trader, the loss is small – about 0.0007, or a bit less than three-quarters of one basis point. In the Canadian market, Malinova, Park, and Riordan (2013) provide direct evidence that retail (and other) traders are, in net, better off when HF traders are trading. Thus, overall, it would appear that HFT has substantially improved the lot of retail investors.

As for institutional traders, a frequent complaint is that HF traders engage in "quote matching"; that is, sniffing out and front-running institutional block trading orders, with the affect of increasing the transitory price changes that result from block trades and hence increasing institutional execution costs. The ability of HF traders to front-run institutional orders in a Canadian setting, however, seems more theoretical than real. The Canadian order protection rule,[26] coupled with the use of smart order routers, effectively creates a consolidated limit order book (across all trading venues) to full depth of book. Unlike in the US, an HF trader seeking to place one or more orders to effect a front running strategy will thus generally be unable to achieve sufficiently high price/time priority to do so. Moreover, even in countries lacking effective order protection, institutional traders are increasingly using sophisticated trading algorithms to disguise their trading activities and to counter attempts by others to detect and front-run their orders. It is thus not surprising that the empirical record suggests that quote-matching does not occur with any great frequency (see, for example, Brogaard 2010). In fact, because HF traders typically trade against transitory price changes, their presence in capital markets reduces, rather than increases institutional execution costs (Hendershott and Riordan 2009). Moreover, as with retail traders, institutional traders benefit from tighter bid/ask spreads, reduced market volatility, and improved price discovery. Thus, institutional traders have also benefited from the presence of HFT.

HFT and Systemic Risk

It has been suggested that the "flash crash" of May 6, 2010, was caused by HF traders and that, more generally, HF traders have increased the likelihood that similar types of events will happen again. Neither proposition appears to be correct.

The "flash crash" resulted from an unusual concatenation of circumstances that is unlikely to be repeated with adequate "circuit-breaker" protection.[27] The crash was initiated by an algorithmic order entered by a large mutual fund to sell some US$4.1 billion in value of E-Mini S&P 500 contracts (an equity futures contract based on the value of the S&P 500) over the Chicago Mercantile Exchange (CME), the only exchange trading this contract then and now. Initially, HF traders were purchasers. Normally, these purchases would have been laid off in a matter of seconds, or perhaps minutes. However, continued sales by the mutual fund created a massive overbalance of sell orders, causing the E-Mini S&P contract to

26 NI 23-101, Article 6.1(1).

27 This is not to say that there were not other structural factors (some unique to the US market) that have not yet been addressed; see, generally, Gomber et al. (n.d.).

decline in value by 3 percent in just four minutes. Then, in the words of the joint SEC/CFTC report into the crash: "Still lacking sufficient demand from fundamental buyers or cross-market arbitrageurs, HFTs began to quickly buy and then resell contracts to each other – generating a 'hot-potato' volume effect as the same positions were rapidly passed back and forth. Between 2:45:13 and 2:45:27, HFTs traded over 27,000 contracts, which accounted for about 49 percent of the total trading volume, while buying only about 200 additional contracts net" (United States 2010).

Arbitrageurs, noting the drop in the E-Mini, began to sell the stocks underlying the index. At this point, many HF traders, who were systematically losing money on their trades, withdrew from the market, leaving it essentially without liquidity. With little but sell orders in the market, the Dow Jones Index plunged nearly 1,000 points. Order was restored when a circuit breaker was triggered at the CME and trading was paused for five minutes. After trading resumed, market normality was restored. The entire sequences of events lasted about half an hour.

The withdrawal of HF traders offering market-maker services was certainly an element of the "flash crash." It thus satisfies a lawyer's "but for" test of factual causation. However, by itself, this observation is relatively meaningless. Again, the question is the marginal, and not the absolute impact of HFT. In a functional sense, one can only say that HF traders "caused" the "flash crash" if they exhibited behaviour that was markedly different from that of traditional market makers, and that a market characterized only by traditional market makers would have fared better. Both propositions seem highly doubtful.

Although impressed with a duty to trade against the market, traditional market makers are not expected to trade against the current indefinitely, or to trade to the full extent of their capital. In the "flash crash," there is no evidence that they remained in the market any longer than the HF traders. Indeed, because HF traders thrive in volatile markets, while traditional market makers do not, there is every reason to believe that HF traders continued to supply liquidity for longer than the traditional market makers. From this perspective, there is no causal connection between the presence of HF traders and the crash.[28]

As indicated in Table 3, the evidence suggests that HF traders do not generally run for the exits when the going gets tough. Numerous studies have found that HF traders do not withdraw liquidity provision when markets are volatile or under stress (see, for example, Brogaard 2010; Groth 2011; Brogaard, Hendershott, and Riordan 2013). In fact, the evidence suggests that HFT profits are higher in a volatile market (Brogaard 2010; Jarnecic and Mark Snape 2010), a potent inducement for HF

28 A study by Kirilenko et al. (2011) is often cited as evidence that HF traders worsened the "flash crash." This interpretation of the study, however, is misleading. As the buy/sell order imbalance worsened, HF traders began to switch from limit to market orders – thus becoming consumers, rather than providers of liquidity. The study finds that market prices were more sensitive to HF traders' market orders than those of fundamental buyers. This is consistent with evidence from other studies that HFT moves market prices more quickly than would otherwise be the case toward fundamental values. The "flash crash" thus can be viewed in part as a set of aberrational circumstances that resulted in a misattribution of informational content to HF market sell orders, when the underlying cause of the high volume of HF traders' market selling was the inability to lay off long positions in the E-Mini S&P 500, given the huge unfilled sell order submitted by the mutual fund trader. In addition, the day of the crash was characterized by an unusually large volume of order "toxicity" – informed trading – that adversely affected the provision of liquidity and acted as an added inducement for HF traders to withdraw liquidity provision (Easley, Lopez de Prado, and O'Hara, 2011).

traders to stay in the market in periods of extreme volatility.[29]

Co-location: Boon or Bane?

Co-location – the practice of HF traders renting server space in the same building as a trading venue's matching engine – reduces to a minimum the time it takes messages to move from the matching engine at the trading venue to the HFT server. Co-location is not so much a new idea as a high-tech iteration of an established practice. The securities trading business has always been an information game. Aggressive business people have long sought ways to ferret out and use information faster than their competitors, using a variety of information technologies such as carrier pigeons, wireless radio transmissions, the telephone, and the Internet.

In the days when trading was effected through human agents, rather than automated trading engines, market professionals rented space from stock exchanges on the trading floor. These professionals would jockey physically for proximity to floor trading posts to maximize their order flow. Co-location merely substitutes computer servers for human agents in the quest for proximity to the trading "floor." Indeed, as pointed out by the Netherlands Authority for the Trading Markets (2010), "the playing field for all the parties co-located on the same platform is level, which was not the case on the physical stock exchange floor between the jobbers." All that is required to create this level playing field is that all co-locating actors be connected by cables of equal length and bandwidth to the trading engine, that co-location be available to any trader that desires it, and that all actors are charged fees on the same basis. It is noteworthy, in this respect, that HF traders are not the only players who are co-locating. Data vendors, as well as sell-side institutions, hedge-funds, and other institutional players are also co-locating. For all of these reasons, co-location does not present any serious policy issues.

Conclusions and Policy Recommendations

HFT enhances market quality. It lowers bid/ask spreads, reduces volatility, improves short-term price discovery, and creates competitive pressures that reduce broker commissions. The following recommendations flow from this conclusion.

IIROC Should Repeal Its Cost Recovery Rule Based on Message Traffic

In April 2012, IIROC introduced a cost recovery fee based on volume of message traffic. Since HF traders generate high message traffic, the burden of this fee structure has fallen disproportionately on them. Malinova, Park, and Riordan (2013) demonstrate that this change in IIROC's fee structure caused a significant reduction in HFT. The abstract of their study states: "The reduction of HFT message traffic causes an increase in spreads and an increase in the trading costs of retail and other traders, or, put differently, HFT

29 A further cause of the "flash crash" – and one having nothing to do with HF trading – is the failure of the US order protection rule to protect full depth of book, rather than just the national best bid or offer. This allows market players to "trade through" orders that are better priced or prior in time through the use of an "intermarket sweep order." See Golub, Poon, and Keane (2013).
The prominent role played by market "internalizers" who purchase retail order flow and execute trades away from the public market may also have been a factor. Internalizers fragment order flow and effectively make it impossible to create a consolidated order book.

activities generate a positive externality and lower other market participants' trading costs." By itself, this would be sufficient reason to repeal the cost recovery fee even if regulatory costs were fully aligned with message traffic, which is open to considerable doubt. Any determination of the marginal cost of regulation based on message traffic is subject to an inevitable element of arbitrariness in attributing various elements of fixed and variable costs to the marginal regulatory cost. In addition, it is highly likely that economies of scale arise in the review of message traffic. As well, the cost each market player is charged depends on the percentage of total market message traffic that each individual player generates during a given month. This not only makes the charge unknowable in advance, but renders each market actor's charges dependent on the message traffic of other market actors over a given period of time. This drives a wedge between marginal regulatory cost and the fee structure. For all of these reasons, the prior fee recovery rule based solely on trading volume should be restored.

Repeal the Locked Market Rule

Canadian rules currently forbid trades from being executed in a "locked market," where bid and ask prices are identical. It is not clear why this is so. In a locked market, by definition, traders on both sides of the market are willing to trade at an agreed-upon price. The greatest beneficiaries of the rule thus appear to be brokers executing client orders, since they are able to earn a bid/ask spread on every trade.[30] In trading venues that use a maker/taker pricing model, HF rebate traders would be perfectly happy to make a market in which the bid/ask spread is zero.

Eliminating the locked market rule would give HF traders an even greater advantage than they now have over traditional market makers or other market incumbents, enhancing the former's profits and diminishing the latter's. However much this gives incumbents an incentive to oppose any change to the locked market rule, the distribution of profits as between different types of market actors is irrelevant from a policy perspective, so long as no market actor is earning economic rents.[31] From a public policy perspective, the main issues at stake are market structure, efficiency, and transaction costs. Abolishing the locked market rule would get rid of an artificial barrier that prevents HF traders from fully exploiting their competitive advantage over incumbent players. It would also reduce transaction costs and facilitate HFT-induced price discovery, thus enhancing market efficiency. Policymakers should repeal the locked market rule.

Focus on Circuit Breakers to Prevent "Flash Crashes"

HF traders did not cause the "flash crash," and indeed are more likely than traditional market markers to remain in the market supplying liquidity when the market becomes highly volatile. The focal point for Canadian regulators concerned with preventing similar events in the future should be circuit breakers designed to stop market anomalies before they turn into "flash crashes."

Rigorously Maintain and Police the Order Protection Rule and Contain the Spread of Dark Pools

The best way to prevent abusive trading practices, protect client interests, and create a level playing

30 The author has received estimates that forced bid/ask spreads cost clients on the order of $100 million or more per month.

31 Bebchuk and Fried define economic rents as "extra returns that firms or individuals obtain due to their positional advantages" (Bebchuk and Fried, 2004, at p.62).

field as between different trading venues (while simultaneously reducing the risk of a flash crash) is to rigorously defend the consolidated order book by maintaining and policing the order protection rule and minimizing the leakage of trading from the "lit" markets to the dark pools. In particular, regulators should resist all attempts to siphon retail trades out of the public market through the use of internalizers or other dark pools. Often motivated by a desire to capture economic rents by excluding HF traders from the market, these practices threaten to nullify the many benefits that have resulted from the presence of HF traders in Canadian capital markets.

Do Not Interfere with Maker/Taker Pricing Models

Some analysts (see for example, Erman 2011) have suggested that maker/taker pricing results in higher trading costs for retail traders, since retail trade orders are typically on the active (or taker) side of the market, and the fee charged active orders is passed on to customers. The logic of this assertion, however, is highly questionable. Historically, retail traders have been about as likely to be on the active as the passive side of the market. Thus, the threshold question is the extent to which maker/taker pricing has altered the passive/active balance. While anecdotal evidence suggests that there has indeed been a marginal effect, maker/taker pricing has also lowered bid/ask spreads. The evidence canvassed above suggests that this has more than compensated retail traders for any disadvantage that might have resulted from a shift in the passive/active balance of retail orders.

In addition, to the extent that retail brokers incur higher trading fees on their active client orders, it is not clear to what extent this cost has been passed on to retail clients. The ultimate burden of the fee charged to the broker by the trading venue depends on the price elasticity of demand for retail brokerage services. If that elasticity is high, as will be the case in a highly competitive market, then brokers are unlikely to be able to pass the full burden of their higher costs on to the customer. Thus, assuming that retail brokerage in Canada is a competitive business, it is likely that brokers have primarily absorbed the burden of the taker fee. While this gives incumbents a reason to complain, securities regulatory policy does not exist to protect any particular type of market actor from competitive forces.

There is good evidence, however, that some of the same retail brokers who vociferously complain about taker fees routinely fail to avail themselves of the opportunity to direct their retail trade to trading venues with significantly lower taker fees. This calls into question both the degree to which retail brokerage markets in Canada are indeed competitive, and the extent to which such brokers genuinely seek to protect their client interests by their complaints about taker fees – as opposed to capturing economic rents by excluding HF traders from the market (or at least making HFT less profitable).

Finally, we are currently in a period in which there is much experimentation in pricing by different trading venues, with a wide variety of different business models in play. Shutting down maker/taker pricing would interfere with the operation of competitive market forces in determining an optimal pricing structure – whether generally, or for particular trading clienteles.

Require Randomization of Trading Venue Preferencing when Different Trading Venues Show Identical Trading Opportunities

The proliferation of HFT has given alternative trading venues a lever with which to compete effectively with more established incumbents. The vigour of this competition, however, is blunted by the ability of broker-dealers with an ownership interest in a particular trading venue to route all orders to that venue in the case of a "tie" with another venue in displayed price/time priority. Competition would be greatly enhanced by requiring that, in the case of a tie in price/time

priority, each trading venue's smart order router randomize the selection of trading venue.[32]

A more modest proposal – although nonetheless one that would lead to significant enhancement in market competition – is to insist that in the case of a tie, the pivotal factor in routing a particular trade would be the comparative trading fees charged by different trading venues. It would seem that retail brokers who complain about the magnitude of taker fees can have little objection to such a change.

32 In the interest of full disclosure, the author is a director of CNSX Markets Inc., the owner of the Pure trading platform.

APPENDIX A

Table A-1: HFT Market Shares from Industry and Academic Studies

Origin	Date of publication	US	Europe	Australia
TABB Group	Sep-09	61%		
Celent	Dec-09	42% of US trade volume	Rapidly growing	
Rosenblatt Securities	Sep-09	66%	~35% and growing fast	
Brogaard	Nov-10	68% of Nasdaq trade volune		
Jarnecic and Snape	Jun-10		20% and 32% of LSE total trades and 19% and 28% of total volume	
Tradeworx	Apr-10	40%		
ASX	Feb-10			10% of ASX trade volume
Swinburne	Nov-10	70%	40%	
TABB Group	Jan-11		35% of overall UK market and 77% of turnover in continous markets	

Source: Gomber, Table 6, p.73.

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