BMO Capital Markets
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The Impact of High Frequency Trading on the Canadian Market

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Introduction

Over the past year the Canadian market has seen the arrival of a new breed of proprietary trading firm using high frequency short term strategies. While many of these new players are using leading edge technology and innovation to trade value added arbitrage strategies that benefit the market as a whole, some of these new entrants are employing predatory strategies that are increasing trading and infrastructure costs for all other market participants, with little or no offsetting benefits.

The purpose of this paper is to highlight some of the predatory strategies currently being employed and to suggest the potential effect such strategies have on the various participants in our markets – clients, issuers, dealers and trading venues.

Arbitrage Litmus Test

Electronic arbitrage strategies have been a part of the Canadian marketplace for many years. In the mid 1990's several Canadian banks began using Quantex terminals and an obscure programming language called Market Mind, to electronically trade inter-listed arbitrage. Since then, a variety of dealers – banks and non-banks alike – have adopted ever improving platforms and programming to trade a variety of arbitrage strategies including ETF, Statistical and Merger Arbitrage. The reader may well be asking how BMO can suggest that other market participant's arbitrage strategies have a negative impact on market quality when we have been running electronic arbitrage ourselves, for many years. We would argue that some arbitrage strategies are positive for the market place while others are potentially very negative. We suggest the following line of demarcation.

Healthy arbitrage includes strategies where the involvement of additional participants results in a net positive impact on the market. For example, if more players enter the ETF arbitrage space they can only succeed by either being faster and / or smarter than existing players, or be willing to do the arbitrage for a lower rate of return. The net result of these new entrants will be tighter spreads, and perhaps greater volume available at the best quote. Strategies like statistical arbitrage link the liquidity in correlated stocks resulting in greater achievable liquidity in many issues. For example, a client trying to buy Royal Bank stock benefits from transacting against an arbitrageur selling the Royal stock to him and subsequently hedging the position by buying TD. This arbitrage strategy ends up benefitting both the arbitrager and the marketplace as a whole.

It stands to reason that any strategy that nets new players benefits the marketplace and is deemed healthy. Unhealthy arbitrage involves strategies where net new players detract from overall market quality. An example of a negative arbitrage strategy is 'Locked Market Passive Rebate Arbitrage'. (See the paper we wrote on Locked Markets). As more participants crowd out passive flow and lock markets to take advantage of the passive rebates it will become much more difficult for liquidity seeking investors to trade on the passive side of the market. This forces them to cross spreads and pay aggressive trading fees resulting in significantly higher trading costs for retail and institutional clients alike. Any uptick in market locking strategies will also cause greater confusion for investors looking at the quote, ultimately harming confidence in the Canadian markets. These strategies are designed to benefit the arbitrageur at the expense of other market participants.

Who Are The High Frequency Traders?

A variety of participants including broker dealer proprietary desks, hedge funds and private proprietary investment firms (sometimes referred to as Electronic Liquidity Providers or ELPs) are currently engaged in HFT. The dealer prop desks and hedge funds have traditionally run automated arbitrage strategies, while the electronic liquidity providers have arrived more recently.

The hedge funds and ELPs running the predatory high frequency strategies range in size from 3 people firms trading just Canada to 500+ employee firms trading multiple asset classes in a variety of geographies. Many of them started out as option trading firms that have parlayed their ability to quickly handle large data feeds – options market data dwarfs equity market data – and efficiently trade automated strategies. **The concern of this paper is with some of the predatory strategies being traded, not with the parties trading them. We are concerned about predatory arbitrage no**

matter who the end client is, and likewise have no issue with more traditional arbitrage traded by any market participant.

How Big Is HFT?

Unlike broker dealers or trading venues that openly advertise their market share numbers in a bid to attract more flow, high frequency traders prefer to trade in relative anonymity. As a result attempting to identify HFT flow and define its size is an art not a science. With that caveat we currently believe that HFT – including both traditional and unhealthy (or predatory) strategies – accounts for roughly 50% of all trading in U.S. equity markets and 35% in Canadian equity markets. If we look only at predatory strategies the numbers would be closer to 35% in the U.S. and 20% in Canada.

Predatory high frequency flow can account for more than 80% of passive flow in some venues (both visible and dark).

The Economics

We start with a quick outline of how exchange pricing currently works. For several years the TSX has used what is referred to as a 'Provider / Seeker pricing model'. In this model, commonly used in the U.S., the exchange charges the aggressive (liquidity-seeking) side of each trade and rebates a fee to the passive (liquidity-providing) side of each trade. This model is currently used by all of the significant visible trading marketplaces in Canada (TSX, Pure, Chi-X, and Alpha).

As the U.S. marketplace discovered several years ago, when multiple marketplaces all adopt this style of pricing model there is a natural incentive for each to inflate the passive rebate – thereby attracting passive flow – and offset the cost of this by inflating the aggressive side fee. The SEC was forced in late 2003 to set rules (SEC 2003-128 later rolled into REG NMS) limiting this inflation, as it was quickly spiralling to the detriment of the market. (One can imagine in a marketplace with strong trade through regulation, a market center that offered a $0.005 rebate for all passive orders and then charged $0.006 for all aggressive orders would quickly earn all the passive orders if all other markets were giving smaller rebates. This results in other marketplaces giving higher rebates, and then others going higher still. Soon the cost to the liquidity-seeking side of the trade would be prohibitive, and would result in market players looking towards other marketplaces to achieve alpha. This creates a drag on the marketplace as a whole – not unlike the drag that stamp taxes have placed on U.K. markets.) After much discussion, the SEC decided to continue allowing passive side rebates, but placed a hard cap of $0.003 / share on the liquidity- taking side of trades for all marketplaces. This forced market venues to compete on innovation, technology, service and net price (difference between passive rebate and aggressive charge) rather than on size of rebate.

Recently several of the Canadian ATSs (and the TSX) have actively courted international HFTs by offering pricing that is advantageous for the passive side of their trades.

Because the passive rebate offered is quoted in hundredths of a penny per share, and is constant for all stocks price over $1, this passive rebate offers a much higher relative reward for liquidity providers on lower priced stocks. As such we have seen significantly greater high frequency trading in stocks below $5 than in higher priced issues. This would partially explain why the 30 lowest priced stocks in the S&P/TSX Composite Index have seen a volume increase of 167% from June 2008 to June 2009, while the remainder of the index has only experienced a volume increase of 35%.

The second part of the equation is the commissions being charged to the High Frequency Traders by some Canadian dealers. We have heard from various participants that some Canadian dealers are charging as little as 5/100ths of a penny per share and placing aggressive caps on the total commission for the month. In these arrangements the clients are responsible for their own technology cost and pay or receive their net exchange fees. These extremely aggressive fee structures allow the High Frequency Traders to remain profitable on trades where their net take is limited to the exchange's passive rebate. The dealers offering these deals typically break even or lose money on the trading but make up for it by monetizing increased market share into investment banking opportunities.

The Need for Speed

The vast majority of the predatory strategies at play rely heavily on creating a speed advantage over other market participants. This speed advantage is created in a variety of ways:

1) Co-Location – Exchanges around the globe have begun offering the ability to Co-Locate computer servers at their site, reducing the latency involved in sending orders, and receiving quote information from the exchange site to their server room and back.

2) Limited Compliance and Risk Filters – While most orders directed to the exchange, either from a dealer's desk or via direct market access (DMA), flow through dealer compliance and risk filters to protect both dealers and clients from sending obviously errant orders that may have devastating results, this is not the case for most HFT flow. These filters add latency of 1 or 2 milliseconds to the order routing process.

3) This unfiltered access – Often referred to as 'Naked Access' – has become a major point of debate in the U.S. with several traditional DMA providers, like Lime Brokerage and LEK Securities, arguing that such Naked Access creates systemic risk and allows certain participants to gain unfair latency advantages.

4) Memory Sharing – At least one U.S. exchange is openly exploring the notion of granting memory sharing to trading firms. Memory sharing involves letting the trading firm share CPU space with the exchange matching engine. As a result the firm that shares CPU space will become aware of a trade or quote change at the exact same moment as the exchange itself. This will allow firms to react instantly to any trade or quote change, before the exchange has even sent a quote change out to data vendors and direct subscribers.

Even if traditional broker dealers co-locate all of their servers, at all of the relevant trading venues, they are highly unlikely to remove compliance and risk monitoring systems meaning they will always be slower than the High Frequency Traders. The HFTs don't need a large speed advantage to take advantage of predictable client flows.

Strategies in Play

The predatory strategies at play range from simple information arbitrage to more complex signalling algorithms that sniff out icebergs and automated orders and then trade ahead of predicted flow. We offer up a description of some of the strategies we have witnessed in the marketplace to give a better understanding of the type of predatory activity we are discussing.

Priority Jumping: Typically smart order routers will send out a fill-or-kill order to take any instantly achievable liquidity and then after assessing their fills will place a passive order at the venue of choice. For example if both venue A and venue B are offering 1000 shares at .50, and we send a buy order for 5,000 at .50 – a spray router will send 2 FOK orders to venue A and B (with some mathematically determined split – lets use a 50/50 split for illustration). If there is no hidden liquidity on either venue, we will receive a partial fill of 1000 shares from both venues and then place a passive order for the remaining 3000 shares. The HFT strategy observes us lifting both offers and instantly bids at .50 predicting that we will be placing a passive order at that level. The HFT has gained time priority over our order, and can use our order to backstop his trading at this level.

This strategy has a limited life as most Canadian dealers are revamping their smart order routers to address this issue.

Algo Sniffing: HFTs are actively sniffing the more predictable of algorithms. Pegging, VWAP and Pouncing algos are quickly identified and the HFT then trades ahead of predicted flow. By way of example an order placed in a pounce algo to lift any offering at .50 or better will quickly be identified by the HFT and they will then react to offerings priced below .50 and offer the stock back out at the client limit. So if the HFT identifies this algo and a seller offers 3,000 shares at 0.48 – the HFT will buy the stock at .48 and offer instantly offer it out at .50. The client will miss the .48 stock due to the HFTs speed advantage and then buy his stock at .50.

Iceberg Sniffing: HFTs are able to identify iceberg orders by looking for an immediate refresh of similar size and price. For example if you place an order to buy 100,000 XYZ at $10.00 displaying 500 shares the HFT will identify the iceberg as soon as it is filled on 500 shares. The instant refresh of 500 new shares bid at the same price make the iceberg order fairly obvious. (Iceberg orders on Pure and TSX are even more obvious because both trading venues publically display the private order number associated with the iceberg.) The HFT will then either join the bid or even penny it, in an attempt to trade off the predicted intentions.

Iceberg sniffing will continue until the visible markets allow for randomization of refresh size and speed (i.e. take some randomized time to display the next 500 shares) and both Pure and TSX stop displaying private order numbers to all participants.

Dark Sub Penny Queue Jumping: HFTs are using continuous dark pools to sub-penny passive orders in the visible book. If for example a client places a size visible bid at .50, the HFT will place a continuous dark pool bid at a fraction of a penny higher. As a result, when an aggressive order flows through the pool they will buy stock at a price less than 1 tick away from the visible bid. They often 'steal' priority away, from the visible bid that created price discovery, by as little as 2/10ths of a penny.

Signalling: HFTs use dark orders or dark pools to create signals of client interest and then trade against this. For example, on a less liquid stock an HFT might place a sell order of 100 shares in a dark pool and if filled use their speed advantage to lift the existing offering. The HFT subsequently offers stock several pennies higher. (We discuss Signalling and Sub Penny Queue Jumping in greater detail in our recent paper on Dark Pools).

Intentional Locking Markets: There are a variety of strategies that employ intentional locked markets to capture the passive rebate paid out by the exchange. While some have argued that a locked market is a perfect market, we believe that locking markets take advantage of the markets overcompensation for passive liquidity to the detriment of liquidity seeking retail and institutional investors.

Impact on Clients

These High Frequency strategies affect traditional liquidity seeking retail and institutional clients in a variety of ways:

1) Market impact costs increase – By far, the most obvious and important effect on clients has been the rise in market impact costs resulting from the predatory strategies. This increased market impact negatively affects overall performance for traditional asset managers and pension funds, the cost of which is ultimately borne by individually investors and pension fund participants.

   This increase in market impact costs is not unique to clients. Dealer desks are experiencing similarly increased market impact costs when trying to flatten positions undertaken to facilitate client orders. In order to avoid increased loss ratios, dealers are force to widen their quote when providing capital further increasing the trading costs to end clients.

2) Liquidity has become less obvious – As predatory high frequency trading creates extra volume without creating additional real liquidity, it become increasing difficult for fund managers to discern the real achievable liquidity in a given stock. To date we have witnessed many instances where portfolio managers looking at total trading volume attempt to buy (sell) too much of a given stock resulting in additional market impact. This cost is again shouldered by the individual end clients.

   We have had several discussions with Canadian buy side accounts who have noted the decreasing effectiveness of their pre-trade analytic tools. Typically these tools rely on volume and a number of other market metrics (e.g. spread, volatility) to predict the impact a given order will have on the market for that issue. As 'real' volume becomes less discernable these tools have greater difficulty determining this number. Portfolio managers, who have become increasingly reliant on these tools over the last several years, are becoming increasingly frustrated with their performance.

3) Tougher to find natural contra flow – Historically buy side accounts trading the Canadian market have enjoyed the unique ability to source liquidity by watching the attributed trading on the exchange. If, for example, client A is a seller of XYZ she can use a variety of data tools to determine which brokers have been the most active buyers in the name, and even determine if they have been trading at current price levels in the last few minutes. This has

allowed clients to make intelligent calls to likely contra side dealers and achieve liquidity with the lowest probability of information leakage. As more Canadian banks offer market access to high frequency participants – we believe that two of the big six are currently doing so – it is becoming increasing difficult for traditional buy side clients to determine which trades are high frequency arbitrage trades versus those that are liquidity seeking trades likely to match up with a contra order.

4) Data and Infrastructure Costs – High frequency strategies tend to send significantly more orders per fill than traditional agency trading algorithms. While an agency trading algorithm may average 5 – 10 orders per fill, some of the high frequency strategies can average hundreds, or even thousands, of orders per fill. These high order-to-fill ratios result in a massive increase in order data that clients must be able to handle. The net effect is an increase in client infrastructure and telecom costs.

Impact on Dealers

Over and above the increased market impact and infrastructure costs detailed above, the dealer community has several additional concerns:

1) Active trading fees are increasing – As the predatory arbitrage strategies make it more difficult to achieve liquidity on the passive side of the quote dealers are forced to cross the spread more regularly. This not only increases the market impact costs for dealers and clients, but also increases the net fee dealers must pay to trading venues. We have had discussions with most of the large Canadian dealers and all of them have expressed concern that their ratio of active to passive orders is increasing on almost all styles of trading. This increased cost will almost certainly force dealers to increase prices (unlikely) or reduce services in order to maintain their profitability.

2) Investment banking at risk to HFT friendly dealers – As stated previously, the sole motivation for facilitating this style of trading is increased market share which is monetized via increased investment banking. As those dealers that have resisted facilitating predatory flow lose out on investment banking mandates, they are heavily incented to offer similar access to HFT participants despite the potential reputational and financial risks.

Impact on Issuers

The issuers, who are the cornerstone of a marketplace, are also negatively impacted in several ways:

1) Confusion around trading – Many of the issuers we talk to are very confused about the increased activity in their stock. As new HFT players start trading their stock, and volumes increase significantly, false take over rumours can circulate which distract management from the day to day operations of their companies.

2) Index composition altered – The major domestic indices – S&P/TSX Composite and 60 – rely on relative liquidity values when making addition and deletion decisions. As such, if trading in lower prices stocks increases relative to that of higher priced issue, those stocks trading at higher prices risk not being added to an index, or being deleted solely based on liquidity filters that don't account for 'real' liquidity but rather use unmassaged volume and value

traded statistics. In June we saw several issues come close to being removed from the Composite index that had not experienced a notable decrease in trading. If this situation continues, HFT strategies will alter index composition towards lower priced issues.

3) Handing out investment banking roles has become increasingly difficult – Traditionally secondary issue mandates were partially awarded based on dealer's market share in the existing stock. The theory behind this was that the dealers most active in the stock were likely to have better relationship with potential investors and to have better market intelligence on the stock thus bringing greater value to the pricing and timing decisions. As some dealers rent out their number to HFT traders and skew the market share tables it is becoming increasingly difficult for issuers to determine which dealers can best aid them in garnering the greatest value from an issuance.

Impact on Trading Venues

Having outlined the negative impact on clients, dealers and issuers we finally come to the one group, other than the HFT players themselves, who are benefitting from this new activity. Globally exchanges and ATSs have experienced significant trading volume growth resulting from this new activity. As trading volume is one of the largest drivers of revenues, and trading volumes amongst traditional asset managers and pension funds have softened since the summer of '08 these new participants have become much coveted clients for all trading venues. As a result trading venues have made changes to fee structures, order types, technologies and access aimed at attracting more high frequency flow to their platform. These changes often come at the expense of traditional market participants. We offer up two examples of trading venues making rule or fee decisions that benefit the HFTs at the expense of traditional liquidity seeking clients:

1) Broker Attribution – The optional attribution of broker numbers allows for clients to effectively source natural contra flow, lowering market impact and minimizing information leakage. Currently one of the ATSs in Canada, Chi-X, does not allow for brokers to put their broker number on any trades done at their venue. We have expressed to Chi-X our problem with this policy and have been informed that they have passive liquidity providers (read HFTs) that do not want broker numbers to be used. HFTs do not like broker numbers as they aid in the discovery of natural liquidity, often resulting in a block trade being done on the upstairs market. These upstairs block trades lower client market impact and are immune to HFT gaming. The HFTs would much rather force a client to work a buy order for 100,000 XYZ on the exchange, trading in many small lots that they can game, than see a block print that they cannot profit from.

2) Trading Fees – Several trading venues have created fees schedules designed specifically to attract HFTs. For example both Pure Trading and Chi-X have passive rebates, on stocks trading under $1, that are a multiple of the passive rebates historically offered by the TSX on stocks at these levels. Currently Pure gives a rebate of $0.0018 and charges an active fee of $0.0022 on these stocks. Chi-X gives a passive rebate of $0.0025 and charges a taker fee of $0.0028. To put that in perspective the TSX gives a rebate of $0.0001 and charges a taker fee of between $0.0006 and $0.0008 depending on the volume tier you are in. (See chart for the fee schedule of all the significant visible pools on stocks below $1) These inflated passive rebates on low priced stocks over compensate liquidity providers creating excessive incentive

for the predatory arbitrage players and taxing clients and dealers who are forced to trade aggressive orders on Chi-X or Pure.

Venue	Passive Rebate	Aggressive Take Fee
TSX	$0.0001	$0.0006 – $0.0008
Chi-X	$0.0025	$0.0028
Pure Trading	$0.0018	$0.0022
Alpha Trading	$0.0001	$0.0007 (5 as of August 3rd)

For stocks trading above $1, the TSX has introduced an Electronic Liquidity Provider (ELP) pricing schedule aimed directly at the HFT firms. This schedule allows HFTs to potentially receive passive rebates 12% higher than the highest rate available to the largest broker dealers. Even Alpha Trading Systems, the ATS owned by Canaccord and the big 6 banks (including BMO) recently announce their intention to increased their passive rebates to court HFT flows.

Mitigating Actions

The entrance of HFTs in the Canadian marketplace has changed the market dynamics. As a result, participants need to be aware of how to reduce the potential impact of the new entrants. We will discuss specific mitigating actions during the life-cycle of a trade as well as ideas for the markets in general. As always, we welcome other suggestions from the industry.

Pre-Trade Mitigating actions:
Average Daily Volumes – Portfolio managers and traders need to understand the effect HFT has on trading volumes, particularly on lower priced stock, and scale back their expectations around volume participation rates.

Market Impact Models –Pre-trade market impact models need to be tweaked to account for the skewed volume numbers in some stocks.

Trade Mitigation actions:
Block Activity – As HFTs negatively impact trades done in the visible market, either manually or via an algorithm, the ability to trade blocks versus contra flow becomes more attractive. Using IOIs and trading activity of non HFT sponsoring dealers to locate potential liquidity can help minimize trading friction.

Algorithms – Smarter algorithms that randomize and hide their flow in the market. Randomizing between anonymous and broker id is a good start. More sophisticated buy side algorithms can randomize between various broker dealer ids and thus make algo sniffing less likely.

Smart Order Routers – Smart order routers need to be tweaked to prevent certain HFT gaming strategies (see priority jumping).

Post-Trade Mitigating actions:
While post trade actions don't directly mitigate the effect of HFTs, the process can be invaluable for monitoring the effect of HFTs on your trading costs. The careful measurement of trading costs can highlight whether mitigating actions during prior steps are working.

Other thoughts:

Index calculations – Index providers need to adjust their liquidity metric to avoid HFTs having undue influence on index composition.

Moral suasion – Industry participants all have a stake in keeping our markets orderly. By better understanding the issues at hand, we can help shape our policies to ensure a market that is fair to all participants and attractive to global investors. We encourage all industry participants to actively participate in the various regulatory debates that are currently taking place, and to voice your dissatisfaction with any participant that is enabling behaviours that are detrimental to the marketplace as a whole.

Conclusion

Automated arbitrage has long added valuable liquidity to the Canadian marketplace, as arbitragers have been able to link liquidity of correlated issues across various marketplaces. Some of the new strategies we are witnessing do not link markets or offer new real liquidity. Instead they use a speed advantage garnered through lower compliance and risk management filters to compete for liquidity with retail and institutional investors whose need for liquidity makes their intentions predictable and therefore game-able. This new predictive liquidity competition acts as a tax on natural market participants, increasing market impact costs, obscuring real achievable liquidity and making natural contra side orders more difficult to locate. The predatory HFTs are being enabled in their venture by exchanges and trading venues desperate for volume and revenue growth.

The purpose of this paper is to educate traders and portfolio managers about the new predatory strategies. We hope that by demonstrating the kinds of predatory strategies that concern us, and highlighting the effect they have on clients, issuers and dealers, we have better armed you to protect yourself accordingly. We are always happy to discuss this matter, or any market structure issue, in far greater detail.

If you have any questions regarding these changes please contact the BMO Quantitative Execution Desk at 416-359-5743

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