Market Integration and High Frequency Intermediation*

Jonathan Brogaard

Terrence Hendershott

Ryan Riordan

First Draft: November 2014

Current Draft: November 2014

Abstract: To date, high frequency trading (HFT) has been studied on individual exchanges. However, HFT firms typically trade across multiple venues. Canadian equity markets are fragmented into several trading venues. The theoretical and empirical literature is mixed on whether fragmentation is detrimental or beneficial to market quality. Recent empirical evidence suggests that the positive (competition) effects of market fragmentation dominate the negative (fragmented and unaccessible liquidity) effects. We study the intersection of the literatures on HFT and fragmentation to help understand the role HFT have in enhancing or harming market quality via market integration/fragmentation. This includes examining several topics related to cross-market behavior of HFT including: (a) their role in cross-market liquidity; (b) multi-market risk (inventory) management; and (c) information transmission across exchanges. Our goal is to fulfill IIROC's desire to better understand how HFT firms affect overall market quality and other investors through their integrated market activity. Early results show HFT are integral in tying markets together.

* We thank Helen Hogarth and Victoria Pinnington IIROC for providing data and comments. All errors are our own.

Contact: Jonathan Brogaard, Foster School of Business, University of Washington, (Email) brogaard@uw.edu , (Tel) 206-685-7822; Terrence Hendershott, University of California – Berkeley, Haas School of Business, (Email) hender@haas.berkeley.edu (Tel) 510-643-0619; and Ryan Riordan, Queen's School of Business, Queen's University (Email) ryan.riordan@queensu.ca (Tel) 705.761.8800.

I. Introduction

This paper examines the role of high frequency trading (HFT) firms in integrating fragmented markets. This includes their role in transmitting information providing liquidity provision, and managing (inventory) risk across multiple trading venues. Recently, fragmented markets behave as if they are integrated with prices moving in lock step. Even without a binding national best bid and offer (NBBO) exchanges rarely deviate much in their posted prices, when one market price moves so do the others. Because markets are not formally linked this implies that market participants are monitoring multiple markets and transferring information and liquidity across markets. Likely candidates for performing this function are HFTs.

Traditional exchange continues to execute order flow but now face a range of competitors for that order-flow. In the U.S. exchanges compete with each other, electronic communications networks (ECN), dark markets, and other execution venues. These changes are not confined to the U.S. markets. In Europe the introduction of MIFID has led to a dramatic fragmentation in order-flow. Even in Canada the previously dominant Toronto Stock Exchange, that enjoyed a near monopoly, have to deal with increasingly fragmented markets. Chi-X, Alpha, and Pure have all captured some of the order-flow with offerings geared towards HFT, retail investors, or institutional investors.

We study the first full trading week in 2012, the week of 01/09/2012 - 01/13/2012. We start with a sample of 150 stocks randomly selected. The stocks are in three market capitalization groups small, medium, and large with 50 stocks in each group. Due to limited trading and quoting activity we drop 12 stocks from our sample leaving us with 138 sample firms.

We identify HFT using a modified version of the Kirilenko et al. (2011) identification algorithm. In total we identify 61 HFT IDs from a total 1706 IDs in the Canadian market. The average HFT is more active in terms of quotes, trades, shares and volume traded, and has a higher order to trade ratio. Overall HFTs hold less inventory throughout and at the end of the trading day. HFTs hold considerably less inventory than their trading would imply. Their end-

of-day inventory is roughly 13% of their traded volume versus 66% for nHFTs. Overall the HFTs we identify are similar to HFTs identified in previous studies.

We identify 7 exchanges on which both HFT and nHFT trade. These exchanges make up 100% of the trading volume in our sample stocks. Trading volume is concentrated in Exchange 2 with 64.29% of the total trading volume. Exchanges 1 and 3 make up the bulk of the remainder of the trading volume with 15.15% and 11.99% respectively. HFT trading activity varies across exchanges. On exchange 2 (the dominant exchange) HFT trade 17.55% of the total volume. On exchange 3 they make up twice as much with 37.78% of the trading volume and on Exchange 1 their share is 24.59%. On the remainder of the exchanges, that trade less than 10% of the volume, HFTs play a lesser role than on the three primary exchanges. In the following information and liquidity analysis we focus on the three exchanges that comprise 91.43% of the total trading volume.

We study the relative contribution to price discovery (information) to the overall market for HFT and non-HFT. We also study the contribution to price discovery of HFT and non-HFT in the three largest individual markets in Canada. Our results show that overall HFT are responsible for impounding between 75.9% and 80.26% of the overall information in our sample of stocks. We also compile price discovery results for each of our three largest exchanges. Information is primarily impounded into prices via quoting on Exchange 1 with an average of 80.3%. If HFTs information share holds across exchanges, then HFT impounds an average of 62% of the total market information through their quoting on Exchange 1.

Next we focus on the importance and role of HFT in overall and cross-market liquidity. Overall spreads are relatively narrow in our sample stocks, with an average of 17.32 basis points. Exchange 2, the dominant exchange has the narrowest spreads overall whereas Exchange 1 and 3 have spreads that are roughly twice the consolidated spread. This highlights that exchanges differ in their supply of liquidity and their contribution to price discovery. We also compile spreads by HFT and exchange and find that HFT contribute less to overall liquidity than do

nHFT. The HFT consolidated spread is 37.11 basis points compared to a spread of 18.09 for nHFT. We compare spreads for HFT and nHFT for each exchange and show that when HFT quote that their spreads are tighter. The results suggest that HFT's quote at the best bid or best ask less than nHFT but that when they do the spreads they quotes are more competitive.

To confirm this conjecture we compile statistics for times when HFT, nHFT or both are quoting at the best bid and best ask. Both HFT and nHFT quote at the best bid or best ask roughly 32-35% of the time. When not both at the best bid or ask HFT only spend roughly 5% of the time at the best bid or ask quotes. The bulk of the time nHFT are at the best bid or ask quoting at the best roughly 55% of the time.

II. Data and Descriptive Statistics

We select 150 firms in three market capitalization categories, small, medium, and large. We look at data for 5 days in 2012. We drop 12 firms from our sample due to data restrictions leaving us with a sample of 138 firms for 5 days, a panel with 690 observations. We report descriptive statistics for nHFT and HFT separately. We identify HFT using the following criteria using a similar identification methodology to Kirilenko et al. (2011) using CFTC data:

(a) Make up more than .25% of trading volume;
(b) Have an end of day inventory of less than 20% of their trading volume; and
(c) Never hold more than 30% of their trading volume at one time within the trading day.

We identify 61 HFT from a total of 1706 trading IDs in Canada.

In Panel A of Table 1 we report statistics for nHFT and for HFT in Panel B. We report averages, medians, 25th percentile, 50th percentile, 75th percentile and standard deviations for an average nHFT (or HFT) per stock and day.

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The average nHFT submits 756 quotes versus 13,960 quotes for the average HFT. nHFT trade roughly 42 times whereas an HFT trades roughly 8 times more per stock and day. Overall HFT are more active in terms of quoting and trading and in terms of their quoting relative to their trading.

We also compare a number of inventory statistics. HFT hold inventory overnight but they hold roughly 1/3 of the overnight inventory of the typical nHFT. The overnight inventory to maximum inventory for an nHFT is roughly 85% versus 48% for HFT. These results suggest that HFT and nHFT manage inventory differently and that this may impact how they operate on financial markets. We also compile statistics that capture inventory in terms of shares traded on a particular day. When nHFT trade they appear to do so to accumulate inventory with between 66% of their trading leading to inventory being held overnight. For HFT only 13.6% of their trading leads to an overnight inventory position. HFT trade in smaller trade sizes than do nHFT 267 shares versus 523 shares for the average nHFT.

The results suggest that HFT in Canada are similar to HFT documented in other jurisdictions.

Canada has a number of markets upon which trading is organized. We identify 9 in total and present summary statistics on the 7 (Exchange 1 to 7) markets on which both HFT and nHFT trade. We report exchange statistics in Panel A of Table 2 and HFT by exchange in Panel B.

INSERT TABLE 2 ABOUT HERE

We report shares trades, dollar volume trades, and shares of both for each exchange. Trading is concentrated on three exchanges 1, 2, and 3. Roughly 65% of the trading share or dollar volume is on Exchange 2, with another 27% traded on Exchanges 1 and 3. The remaining 4 exchanges trade less than 10% of the total trading volume.

In Panel B we report similar statistics for HFT by Exchange. We find that HFT trade most on Exchange 3 making up roughly 35% of the traded volume. HFT trade 25% on Exchange 1 and roughly 16% on the primary exchange. HFT trading activity does not appear to be proportionately distributed across the three main exchanges suggesting that they may prefer certain features of different markets.

III. Results

We report two sets of results addressing two important factors of market quality; (1) price discovery, and (2) liquidity. Price discovery is the study of who and where information is impounded into prices and is one of the most important functions of a market. Liquidity captures the cost of buying and selling securities and is an important factor in any investment strategy.

a. Price Discovery

We perform a standard analysis of price discovery that captures the contribution of HFT and nHFT quotes to price discovery. The standard way to measure the contribution to price discovery using the quotes of various participants and/or on different venues is the information shares approach of Hasbrouck (1993). The information shares approach breaks down total information into individual parts attributable to specific markets or participants as follows:

$$infoShare_j := \frac{\Psi_j^2 \Omega_j}{\Psi \Omega \Psi'}$$

Where infoShare_j the percent of information attributable to participant or market j; the numerator is the total share of the variance of the efficient price attributable to participant j; and the denominator is total variance of the efficient price. The variance of the efficient price is the change in price over the day with the noise component removed.

The results of the information share are easy to interpret in terms of percent capture all of the information attributable to a participants' quoting activity. Table 3 reports the minimum and maximum information for HFT and nHFT.

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We find the HFT lead price discovery. HFT are responsible for at least 75.94% of the total market information and at most 80.26%. nHFT are responsible for between 19.64% and 23.96%. Even using the most conservative estimate for HFT and the least conservative estimate to nHFT, HFT quoting is responsible for roughly 3 times the price discovery of nHFT.

The results are interesting because HFT trades roughly 22% of the total volume but impounds more than 75% of the information. The results suggest that the quoting activities of HFT help to improve the efficiency of markets.

We also compile information shares by exchange for the three largest exchanges. We report minimum and maximum information shares. The results are surprising in that they suggest that price discovery happens almost exclusively on Exchange 1 with roughly 15% of volume and not Exchange 2 that has more than 60% of the trading volume. The results are not entirely unexpected; Barclay, Hendershott, and McCormick (2003) show that in the U.S. electronic communications networks with lower volume than the Nasdaq dominate price discovery.

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Surprisingly the highest volume markets contributes least to price discovery. The markets in which HFT trade more frequently are responsible for impounding more information than the dominant trading market.

b. Liquidity

We report the consolidated quoted spread and the quoted spread for each of the three dominant markets in Table 5.

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The mean consolidated quoted spread is 17.32 basis points and the median is roughly 10.3 basis points. Exchange 2, the dominant exchange, has the narrowest spreads at 19.29 basis points. Both exchanges 1 and 3 have spreads that are roughly twice that of the Exchange 2. Quoted spreads on Exchange 2 are very close to the consolidated quoted spread indicating that liquidity is predominantly supplied on Exchange 2. These results are in contrast to the price discovery results that suggest that information is impounded on the exchange that is less liquid.

The quoted spread results broken down by HFT and nHFT and by HFT, nHFT and by market are reported in Table 6.

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The consolidated quoted spread for HFT are roughly twice that of the nHFT spread. HFT appear to be driving price discovery but they are less important in terms of liquidity supply. We break down HFT and nHFT spread by exchange. We report spreads only for times during which HFT or nHFT supply bids or asks on both sides of the market. This type of analysis shows that when HFT supply two sided quotes that their quotes are tighter than for nHFT when they submit two-sided spreads. The fact that the consolidated results show the opposite suggests that HFT do not supply liquidity throughout the trading day and that they may strategically reduce their liquidity supply under certain conditions.

To test the conjecture that HFT are less often at the best bid or ask we compile statistics that report who is at the best bid or ask in seconds.

INSERT TABLE 7 ABOUT HERE

We report the percent of time when both HFT and nHFT are at the best bid or ask and for when only HFT or nHFT are at the best bid or best ask. The results confirm our previous conjecture that HFT spend less time at the best bid or best ask. Both HFT and nHFT spend roughly 35% percent of the trading day at the best bid or best ask. HFT only spend between 12% and 8% of the time at the best bid or best ask respectively.

c. High Volume Stocks

Brogaard, Hendershott, and Riordan (2014) show that HFT are active in high volume and high market capitalization stocks. We report information shares by HFT and by exchange for the 46 highest volume stocks. We also report the quoted spread and time at the best bid and best ask by HFT and by exchange for the 46 highest volume stocks. In Table 8 we report HFT and nHFT information shares as in Table 3.

INSERT TABLE 8 ABOUT HERE

The table shows that HFT increase their contribution to price discovery in high volume stocks. In Table 9 we report information share statistics similar to those reported in Table 4.

INSERT TABLE 9 ABOUT HERE

Here we can show that information shares are higher on Exchange 1 for the highest volume stocks, showing that HFT trade more on Exchange 1 and that in doing so they increase the share of price discovery on the Exchange.

In Table 10 we report quoted spread statistics similar to those reported in Table 7 but for only high volume stocks.

INSERT TABLE 10 ABOUT HERE

The results are similar to those reported in Table 6 with the exception that the spreads HFT offer in the individual markets are much narrower than nHFT spreads. The results do confirm that HFT are strategic in high volume and low volume stocks and often stop supplying liquidty.

To confirm the fact that HFT spend less time at the best bid and best ask we perform an analysis similar to that reported in Table 7.

INSERT TABLE 11 ABOUT HERE

HFT and nHFT spend more time together at the best bid and best ask than for lower volume stocks, roughly 46.5% of the time. HFT spend more time at the best bid and best ask in high volume stocks than in low volume stocks but still less time than do nHFT. In short the liquidity results are not overturned when looking at high volume stocks only.

IV. Conclusion

We select 150 firms that trade in Canada on 7 exchanges. We identify 61 IDs that exhibit behaviors that are consistent with our priors on how HFT trade. We find that these IDs are responsible for much of the message traffic on exchanges and trade frequently. They hold little inventory and appear to trade for reasons other than inventory accumulation, i.e. long-term investing.

Using data provided by the Investment Industry Regulatory Organization of Canada (IIROC) we identify HFT in a cross section of stocks across multiple markets. We find that HFT are

responsible for the bulk of price discovery but that they are less important for liquidity. The results hold when we select the highest volume stocks in our sample of firms.

References

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Table 1: Descriptive Statistics. We report descriptive statistics for 138 firms for the week of 01/09/2012 - 01/13/2012. In Panel A we report statistics for non-HFT and for HFT in Panel B.

Panel A: Non HFT

	Mean	Median	25%	75%	Std. Dev.
Number of Quotes	756	22	4	237	9,684
Number of Trades	42	8	2	32	121
Number of Shares Traded	12,180	1,500	375	6,400	75,933
Dollar Volume Traded	310,716	36,016	8,165	165,068	1,734,818
Quote to Trade ratio	18	3	2	7	80
End of Day Inventory	5,909	630	172	2,900	30,618
Max Intraday Inventory	6,925	1,000	300	3,800	34,812
EoD Inv / Shares Traded	66.77%	85.58%	33.33%	100.00%	37.04%
Max Intra. Inv. / Shares Traded	77.16%	100.00%	50.00%	100.00%	29.31%
Average Trade Size	523	133	100	225	6,668
Number of nHFT = 1,645					

Panel B: HFT

	Mean	Median	25%	75%	Std. Dev.
Number of Quotes	13,960	2,430	82	15,510	30,527
Number of Trades	347	121	26	390	626
Number of Shares Traded	54,016	16,500	3,600	55,550	120,623
Dollar Volume Traded	1,524,784	386,382	77,798	1,374,933	3,313,835
Quote to Trade ratio	40	20	3	40	49
End of Day Inventory	1,849	400	100	1,300	6,825
Max Intraday Inventory	3,763	1,500	600	3,200	11,233
EoD Inv / Shares Traded	13.60%	3.27%	0.64%	12.50%	24.70%
Max Intra. Inv. / Shares Traded	21.26%	10.94%	4.82%	25.00%	25.90%
Average Trade Size	267	117	100	153	1,745
Number of HFT = 61					

Table 2: Activity by Exchange. We report activity statistics for each of 7 exchanges for 138 firms for the week of 01/09/2012 - 01/13/2012. In Panel A we report for all exchanges and in Panel B for HFT activity on each of the exchanges.

Panel A: Exchange Volume

Exchange	Variable	Mean	Median	25th %	75th %
1	Shares Traded	1,578	1,578	1,578	1,578
1	Dollar Volume Traded	40,051	40,051	40,051	40,051
1	% Shares Traded	15.54%	15.54%	15.54%	15.54%
1	% Dollar Volume traded	15.15%	15.15%	15.15%	15.15%
2	Shares Traded	6,423	6,423	6,423	6,423
2	Dollar Volume Traded	169,917	169,917	169,917	169,917
2	% Shares Traded	63.25%	63.25%	63.25%	63.25%
2	% Dollar Volume traded	64.29%	64.29%	64.29%	64.29%
3	Shares Traded	1,213	1,213	1,213	1,213
3	Dollar Volume Traded	31,699	31,699	31,699	31,699
3	% Shares Traded	11.94%	11.94%	11.94%	11.94%
3	% Dollar Volume traded	11.99%	11.99%	11.99%	11.99%
4	Shares Traded	146	146	146	146
4	Dollar Volume Traded	3,536	3,536	3,536	3,536
4	% Shares Traded	1.44%	1.44%	1.44%	1.44%
4	% Dollar Volume traded	1.34%	1.34%	1.34%	1.34%
5	Shares Traded	337	337	337	337
5	Dollar Volume Traded	8,757	8,757	8,757	8,757
5	% Shares Traded	3.31%	3.31%	3.31%	3.31%
5	% Dollar Volume traded	3.31%	3.31%	3.31%	3.31%
6	Shares Traded	219	219	219	219
6	Dollar Volume Traded	5,098	5,098	5,098	5,098
6	% Shares Traded	2.15%	2.15%	2.15%	2.15%
6	% Dollar Volume traded	1.93%	1.93%	1.93%	1.93%
7	Shares Traded	240	240	240	240
7	Dollar Volume Traded	5,251	5,251	5,251	5,251
7	% Shares Traded	2.36%	2.36%	2.36%	2.36%
7	% Dollar Volume traded	1.99%	1.99%	1.99%	1.99%

Panel B: HFT Volume by Exchange

Exchange	Variable	Mean	Median	25th %	75th %
1	HFT Shares Traded (100,000)	378	378	378	378
1	HFT Dollar Volume Traded ($100,000)	9,847	9,847	9,847	9,847
1	% Shares Traded by HFT	23.92%	23.92%	23.92%	23.92%
1	% Dollar Volume traded by HFT	24.59%	24.59%	24.59%	24.59%
2	HFT Shares Traded (100,000)	1,016	1,016	1,016	1,016
2	HFT Dollar Volume Traded ($100,000)	29,822	29,822	29,822	29,822
2	% Shares Traded by HFT	15.82%	15.82%	15.82%	15.82%
2	% Dollar Volume traded by HFT	17.55%	17.55%	17.55%	17.55%
3	HFT Shares Traded (100,000)	430	430	430	430
3	HFT Dollar Volume Traded ($100,000)	11,975	11,975	11,975	11,975
3	% Shares Traded by HFT	35.50%	35.50%	35.50%	35.50%
3	% Dollar Volume traded by HFT	37.78%	37.78%	37.78%	37.78%
4	HFT Shares Traded (100,000)	13	13	13	13
4	HFT Dollar Volume Traded ($100,000)	333	333	333	333
4	% Shares Traded by HFT	9.23%	9.23%	9.23%	9.23%
4	% Dollar Volume traded by HFT	9.41%	9.41%	9.41%	9.41%
5	HFT Shares Traded (100,000)	56	56	56	56
5	HFT Dollar Volume Traded ($100,000)	1,495	1,495	1,495	1,495
5	% Shares Traded by HFT	16.55%	16.55%	16.55%	16.55%
5	% Dollar Volume traded by HFT	17.07%	17.07%	17.07%	17.07%
6	HFT Shares Traded (100,000)	7	7	7	7
6	HFT Dollar Volume Traded ($100,000)	179	179	179	179
6	% Shares Traded by HFT	3.35%	3.35%	3.35%	3.35%
6	% Dollar Volume traded by HFT	3.51%	3.51%	3.51%	3.51%
7	HFT Shares Traded (100,000)	26	26	26	26
7	HFT Dollar Volume Traded ($100,000)	732	732	732	732
7	% Shares Traded by HFT	10.90%	10.90%	10.90%	10.90%
7	% Dollar Volume traded by HFT	13.94%	13.94%	13.94%	13.94%

Table 3: Information Shares by HFT. We report information shares for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate information shares for HFT and nHFT and report the minimum and maximum values. Standard errors are calculated using errors that account for autocorrelation and cross-sectional correlation in the residuals. *** Represents statistical significance at the 1% level.

	Min	Max
HFT	75.94%***	80.26%***
nHFT	19.64%	23.96%

Table 4: Information Shares by Exchange. We report information shares for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate information shares for the 3 largest exchanges and report the minimum and maximum values. Standard errors are calculated using errors that account for autocorrelation and cross-sectional correlation in the residuals. All coefficients are statistically significantly different than zero.

	Min	Max
Exchange 1	78.35%	82.44%
Exchange 2	4.40%	8.84%
Exchange 3	11.13%	15.82%

Table 5: Quoted Spreads Overall and by Market. We report quoted spreads for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate quoted spreads overall and for the three largest exchanges.

Exchange	Variable	Mean	Median	25th %	75th %
Consolidated	Quoted Spread	17.32	10.30	6.22	19.53
Exchange 1	Quoted Spread	34.79	23.68	8.33	51.66
Exchange 2	Quoted Spread	19.29	11.46	6.89	22.21
Exchange 3	Quoted Spread	33.36	23.04	9.19	44.38

Table 6: Quoted Spreads for HFT and nHFT and Overall and by Market. We report quoted spreads for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate quoted spreads overall and for the three largest exchanges for HFT and nHFT.

Exchange	Variable	Mean	Median	25th %	75th %
Consolidated	HFT Quoted Spread	37.11	19.89	8.13	69.57
Consolidated	nHFT Quoted Spread	18.09	11.25	6.57	20.14
Exchange 1	HFT Quoted Spread	27.22	12.95	7.10	37.15
Exchange 1	nHFT Quoted Spread	50.85	50.71	30.30	64.33
Exchange 2	HFT Quoted Spread	33.07	16.99	8.74	49.39
Exchange 2	nHFT Quoted Spread	47.61	47.17	30.62	59.95
Exchange 3	HFT Quoted Spread	27.30	13.56	8.02	38.36
Exchange 3	nHFT Quoted Spread	40.66	33.57	20.43	52.77

Table 7: HFT and nHFT Time at the Best Bid and Ask. We report proportion time at the best bid and best ask for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate time where both HFT and nHFT are at the best together, and alone.

Variable	Mean	Median	25th %	75th %
Both Bid	0.35	0.36	0.10	0.56
Both Ask	0.33	0.35	0.07	0.55
HFT Bid Time	0.12	0.06	0.01	0.17
nHFT Bid Time	0.53	0.48	0.23	0.87
HFT Ask Time	0.08	0.04	0.01	0.12
nHFT Ask Time	0.58	0.54	0.31	0.90

Table 8: Information Shares by HFT. We report information shares for an average of the highest volume stocks for the week of 01/09/2012 - 01/13/2012. We calculate information shares for HFT and nHFT and report the minimum and maximum values. Standard errors are calculated using errors that account for autocorrelation and cross-sectional correlation in the residuals. *** Represents statistical significance at the 1% level.

	Min	Max
HFT	83.81%***	86.79%***
nHFT	13.11%	16.09%

Table 9: Information Shares by Exchange. We report information shares for an average of the highest volume stocks firms for the week of 01/09/2012 - 01/13/2012. We calculate information shares for the 3 largest exchanges and report the minimum and maximum values. Standard errors are calculated using errors that account for autocorrelation and cross-sectional correlation in the residuals. All coefficients are statistically different than zero.

	Min	Max
Exchange 1	82.52%	83.37%
Exchange 2	4.39%	4.93%
Exchange 3	11.94%	12.56%

Table 10: Quoted Spreads for HFT and nHFT and Overall and by Market for High Volume Stocks. We report quoted spreads for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate quoted spreads overall and for the three largest exchanges for HFT and nHFT for high volume stocks.

Exchange	Variable	Mean	Median	25th %	75th %
Consolidated	HFT Quoted Spread	8.17	6.14	3.76	9.18
Consolidated	nHFT Quoted Spread	6.33	5.42	3.76	8.40
Exchange 1	HFT Quoted Spread	7.89	6.54	4.18	10.52
Exchange 1	nHFT Quoted Spread	35.50	30.19	20.84	53.72
Exchange 2	HFT Quoted Spread	8.85	7.10	4.16	10.20
Exchange 2	nHFT Quoted Spread	28.42	23.03	15.26	39.53
Exchange 3	HFT Quoted Spread	8.21	7.34	4.27	10.79
Exchange 3	nHFT Quoted Spread	21.74	18.30	11.03	28.42

Table 11: HFT and nHFT Time at the Best Bid and Ask. We report proportion of time at the best bid and best ask for an average of 138 firms for the week of 01/09/2012 - 01/13/2012. We calculate time where both HFT and nHFT are at the best together, and alone for the highest volume stocks.

Variable	Mean	Median	25th %	75th %
Both Bid	0.48	0.48	0.36	0.61
Both Ask	0.45	0.48	0.34	0.58
HFT Bid Time	0.24	0.19	0.11	0.35
nHFT Bid Time	0.29	0.22	0.14	0.40
HFT Ask Time	0.15	0.12	0.07	0.21
nHFT Ask Time	0.40	0.35	0.21	0.54