Interactions Among High Frequency Traders

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the UK Financial Conduct Authority or the Federal Reserve Board
Rise of the machines?

Source: sniperinmahwah.wordpress.com

Benos, Brugler, Hjalmarsson, Zikes, 2017
Rise of the machines?
Why do we care?

• The rise of computer-based algorithmic trading (AT) in general and HFT in particular, is one of the most significant developments in modern financial markets.
• Some estimates have HFT accounting for up to 60% of US equity volume.
• Of obvious importance is the impact of HFT activity on market quality:
  – Price efficiency
  – Liquidity
• “Flash Boys”, 2014
Why do we care?

May 6, 2010, NYSE: “Flash Crash”

SPY Volume and Price

Source: SEC-CFTC

Benos, Brugler, Hjalmarsson, Zikes, 2017
What we do

• We assess the degree of HFT correlated trading on the LSE and its impact on price efficiency
  – Are HFTs trading the same stocks, in the same direction, at the same time?
  – If yes, what is the impact of this on price efficiency?

• We use proprietary (FCA) transaction data that identifies HFTs active on the LSE
  – Thus we overcome some of the limitations faced by previous studies

Benos, Brugler, Hjalmarsson, Zikes, 2017
What we find

- HFT order flow, volume and net positions are significantly more correlated than those of a control group of investment banks.

- HFT order flow commonality is associated with permanent price impacts suggesting that it is information-based and does not generally contribute to undue price pressure and price dislocations.

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Data

Sample:
• 92 FTSE 100 index stocks
• 4 months (Sep 1 – Dec 31 2012)

FCA ZEN Database (proprietary)
• Transactions executed on the LSE by EU-regulated entities.
• Time stamped to the closest second, price, size, B/S indicator
• Counterparty identities
• Missing data for non-EU regulated entities
• 25.2m observations

Bloomberg Database (public)
• Transactions and best quotes data
• Time stamp (closest second), correct sequence for same-second trades, price, size (only for trades), venue
• No counterparty identities
• Used to reconstruct top of the order book to identify the initiator of a trade via the Lee-Ready algorithm.

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HFT Identification

• From the 1,200 reporting firms we identify 28 as HFT
  – Identification from discussions with FCA market supervisors
  – Within this group we identify **10 HFTs** that collectively account for more than 95% of the entire volume of the group
  – These HFTs account for about 25% of volume in our data; this is similar to the 25-30% market share of the group of pure HFTs identified by Hagstromer and Norden (2013) on NASDAQ-OMX Stockholm

• We do not pick up HFT trading within large financial conglomerates (e.g. investment banks and multi-desk hedge funds)

• We also use as a control group the 10 largest (by turnover) Investment Banks as per Markit MSA broker rankings.

Benos, Brugler, Hjalmarsson, Zikes, 2017
## Summary statistics

### Sep – Dec 2012 / per firm-stock-day

<table>
<thead>
<tr>
<th></th>
<th>HFT</th>
<th>IB</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std.</td>
<td>Mean</td>
</tr>
<tr>
<td>Volume (Shares ’000)</td>
<td>188.13</td>
<td>1,108.36</td>
<td>288.70</td>
</tr>
<tr>
<td>Volume (GBP ’000)</td>
<td>842.5</td>
<td>1,790.2</td>
<td>1,344.5</td>
</tr>
<tr>
<td>Number of trades per day</td>
<td>145.4</td>
<td>251.0</td>
<td>215.3</td>
</tr>
<tr>
<td>Trade size (GBP)</td>
<td>5,455</td>
<td>7,207</td>
<td>5,527</td>
</tr>
<tr>
<td>Absolute daily position change (GBP ’000)</td>
<td>133.3</td>
<td>349.6</td>
<td>455.6</td>
</tr>
<tr>
<td>Ratio of absolute position change to volume (GBP/GBP)</td>
<td>0.16</td>
<td>0.23</td>
<td>0.35</td>
</tr>
<tr>
<td>Zero-inventory crossings per day</td>
<td>7.28</td>
<td>17.52</td>
<td>2.21</td>
</tr>
</tbody>
</table>

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Is HFT activity correlated?

**Model:**

- Trade-time VAR:

\[
\begin{bmatrix}
\text{HFT}_t^s \\
\text{IB}_t^s \\
M_t^s
\end{bmatrix} = \mu^s + \sum_{k=1}^{10} \begin{bmatrix} 
A_{11,k} & A_{12,k} & A_{13,k} \\
A_{21,k} & A_{22,k} & A_{23,k} \\
A_{31,k} & A_{32,k} & A_{33,k}
\end{bmatrix} \begin{bmatrix}
\text{HFT}_{t-k}^s \\
\text{IB}_{t-k}^s \\
M_{t-k}^s
\end{bmatrix} + \Lambda X_{t-1}^s + \Psi G_t + \epsilon_t^s.
\]

where:

\[
\begin{bmatrix}
\text{HFT}_t^s \\
\vdots \\
\text{HFT}_{10,t}^s
\end{bmatrix} \quad \text{and} \quad \begin{bmatrix}
\text{IB}_t^s \\
\vdots \\
\text{IB}_{10,t}^s
\end{bmatrix}
\]

- Activity variables: *order flow*, volume, position change
- Temporal ordering of events & no bias due to temporal aggregation
- Estimated by pooling across all stocks & allowing for stock-specific intercepts
- Controls: 10-trade Cum. return, volatility, avg. spread & depth, time dummies
- Inference: Bootstrap at a daily level

Benos, Brugler, Hjalmarsson, Zikes, 2017
## Is HFT activity correlated?

<table>
<thead>
<tr>
<th>Hypothesis to be tested</th>
<th>Order flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficients</td>
</tr>
<tr>
<td>1. Are HFTs correlated within stocks?</td>
<td>0.7529</td>
</tr>
<tr>
<td>2. Are IBs correlated within stocks?</td>
<td>0.0506</td>
</tr>
<tr>
<td>3. Are HFTs more correlated than IBs?</td>
<td>0.7023</td>
</tr>
<tr>
<td>4. Do HFTs respond to IBs?</td>
<td>0.3059</td>
</tr>
<tr>
<td>5. Do IBs respond to HFTs?</td>
<td>0.2848</td>
</tr>
<tr>
<td>6. Do HFTs respond differently to IBs than IBs do to HFTs?</td>
<td>0.0210</td>
</tr>
</tbody>
</table>

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Is HFT activity correlated?

- HFT dynamic relationship concentrated in first few lags
- Results robust to alternative lag horizons

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What is the impact on price efficiency?


\[
\text{CorrTrading}_{s,t}^{\text{HFT}} = N(\text{Buy})_{s,t}^{\text{HFT}} - \frac{N(\text{Buy})_{s,t}^{\text{HFT}} + N(\text{Sell})_{s,t}^{\text{HFT}}}{2}
\]

- Where \( N(\text{Buy})_{s,t}^{\text{HFT}} \) is the number of aggressive HFT buyers in stock \( s \), in time period \( t \)

- An HFT is classified as an “aggressive” buyer if its aggressive buy volume is greater than its aggressive sell volume

- The metric captures the number of excess aggressive buyers/sellers relative to a situation where HFTs randomly buy and sell with equal probability and independently of each other: [10 aggr. HFTs, 7 buyers \( \rightarrow \) CorrTrading = +2]

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What is the impact on price efficiency?

**Model:**

2. Price Impact regressions (estimated over 1- & 5-minute intervals):

\[
R_{s,t} = \alpha_s + \sum_{i=0}^{5} \beta_{OF,i}^{HFT} OF_{s,t-i}^{HFT} + \sum_{i=0}^{5} \beta_{OF,i}^{IB} OF_{s,t-i}^{IB} + \sum_{i=1}^{5} \beta_{OF,i}^{Res} OF_{s,t-i}^{Res} \\
+ \sum_{i=0}^{5} \beta_{Corr,i}^{HFT} CorrTrading_{s,t-i}^{HFT} + \sum_{i=0}^{5} \beta_{Corr,i}^{IB} CorrTrading_{s,t-i}^{IB} \\
+ \sum_{i=0}^{5} \beta_{Corr,i}^{HFT} CorrTrading_{s,t-i}^{HFT} + \sum_{i=0}^{5} \beta_{Corr,i}^{IB} CorrTrading_{s,t-i}^{IB} \\
+ \sum_{i=0}^{5} \beta_{OF}^{HFT} Corr_{s,t-i} \left( OF_{s,t-i}^{HFT} \times \left| CorrTrading_{s,t-i}^{HFT} \right| \right) \\
+ \sum_{i=0}^{5} \beta_{OF}^{IB} Corr_{s,t-i} \left( OF_{s,t-i}^{IB} \times \left| CorrTrading_{s,t-i}^{IB} \right| \right) + u_{s,t}.
\]

- Estimated by pooling across stocks
- Stock-specific intercepts

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HFT correlated trading and price efficiency

<table>
<thead>
<tr>
<th></th>
<th>OF$_{t}^{HFT}$</th>
<th>OF$_{t-1,t-5}^{HFT}$</th>
<th>OF$_{t}^{IB}$</th>
<th>OF$_{t-1,t-5}^{IB}$</th>
<th>OF$_{t}^{RES}$</th>
<th>OF$_{t-1,t-5}^{RES}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.439</td>
<td>0.351</td>
<td>0.378</td>
<td>(-0.039)</td>
<td>-0.040</td>
<td>-0.023</td>
</tr>
<tr>
<td></td>
<td>(149.8)</td>
<td>(126.4)</td>
<td>(107.2)</td>
<td>(-11.71)</td>
<td>(-11.31)</td>
<td>(-5.310)</td>
</tr>
<tr>
<td></td>
<td>0.473</td>
<td>0.384</td>
<td>0.410</td>
<td>(-0.075)</td>
<td>-0.046</td>
<td>-0.046</td>
</tr>
<tr>
<td></td>
<td>(179.6)</td>
<td>(190.1)</td>
<td>(159.6)</td>
<td>(-37.86)</td>
<td>(-21.03)</td>
<td>(-16.74)</td>
</tr>
<tr>
<td></td>
<td>0.519</td>
<td>0.466</td>
<td>0.457</td>
<td>(-0.071)</td>
<td>-0.058</td>
<td>-0.058</td>
</tr>
<tr>
<td></td>
<td>(156.9)</td>
<td>(157.1)</td>
<td>(155.9)</td>
<td>(-28.57)</td>
<td>(-23.98)</td>
<td>(-23.94)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CorrTrading$_{t}^{HFT}$</th>
<th>CorrTrading$_{t-1,t-5}^{HFT}$</th>
<th>CorrTrading$_{t}^{IB}$</th>
<th>CorrTrading$_{t-1,t-5}^{IB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.186</td>
<td>0.203</td>
<td>0.310</td>
<td>0.324</td>
</tr>
<tr>
<td></td>
<td>(45.72)</td>
<td>(47.23)</td>
<td>(85.08)</td>
<td>(83.93)</td>
</tr>
<tr>
<td></td>
<td>0.017</td>
<td>0.026</td>
<td>-0.154</td>
<td>-0.155</td>
</tr>
<tr>
<td></td>
<td>(3.024)</td>
<td>(4.389)</td>
<td>(-48.42)</td>
<td>(-48.99)</td>
</tr>
</tbody>
</table>

Wald test $H_0: \beta_{Corr,0}^{HFT} = \beta_{Corr,0}^{IB}$ (p-values) = 0.000
Wald test $H_0: \sum_{i=1}^{5} \beta_{Corr,i}^{HFT} = \sum_{i=1}^{5} \beta_{Corr,i}^{IB}$ (p-values) = 0.000

1-min specification shown above; 5-min results similar

• HFT correlated trading associated with a permanent price impact
• IB correlated trading associated with price reversals
• HFT correlated trading is likely information-driven and contributes to price efficiency!
Summary

• We find that at high-frequencies, HFT order flows in a given stock are positively correlated and significantly more so than a control group of IBs

• HFT correlated trading is associated with a permanent price impact, IB correlated trading is associated with price reversals

• This suggests that HFT correlated trading is information-driven and unlikely to contribute to undue price pressure and price dislocations on a regular and ongoing basis

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Limitations & further research..?

- We only focused on the LSE - how do HFTs trade across the four main trading venues in the UK (Chi-X, BATS, Turquoise)?

- We only focused on a period of relative market calm. What impact does HFT correlated trading have at times of stress?
THANK YOU!