Market quality in the time of algorithmic trading

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The problem

- Since 2000, escalating use of technology in trading on equities markets.
- AT now dominates exchanges worldwide. Concerns about reduced liquidity, ‘flash crashes’, etc.
- Regulators all over the world are contemplating interventions on AT.
- In search of finding a market failure that justifies regulatory intervention, numerous researchers have asked: What is the effect of AT on liquidity and volatility?
- Main findings: AT generally lowers transactions costs. AT may or may not improve depth. AT may or may not lower volatility.
- Weaknesses of this literature.
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Solving the weaknesses of the literature

A design that solves the weaknesses of the literature:

1. *Clean microstructure*: An exchange with 80% market share of all trading, one of the largest exchange in the world by transaction intensity.

2. *An exogenous event*: Introduction of co-location services in Jan 2010, which was followed by an S-curve of adoption.

3. *Recording data well*: Perfect data with every order tagged as “AT” or “non-AT” for every security at the exchange.
Methodology

- Use the AT flag on the orders and trades to measure the AT intensity, both security specific and market average.
- Use the introduction of co-location services (CO-LO) — January 2010 — to divide the time period into low and high AT-INTENSITY periods.
- Pick a sample of one month from the period of low and from the high AT-INTENSITY as the LOW-AT and HIGH-AT samples.
- The difference between the market quality in the HIGH-AT and LOW-AT samples can be attributed to the rise of AT.
- Control for changes in other things such as macroeconomic conditions.
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What we find

- AT-INTENSITY in the market rose significantly after the introduction of co-lo but stabilised with a significant lag.
- On average, the intra-day market quality measures
  - Improved: transactions costs (spread, impact cost), risk (intraday volatility, volatility of impact cost).
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Implementation details
Data

- Period:
  - Pre co-lo: Jan ’09 to Dec ’09
  - Post co-lo: Jul ’12 to Aug ’13

- Sample of stocks: CNX100 (as in 2012)

- Sample period analysed: (One month sample)
  - LOW-AT PERIOD: Jul 6, 2009 to Aug 8, 2009 (23 trading days)
  - HIGH-AT PERIOD: Jul 6, 2012 to Aug 8, 2012 (25 trading days)

- Frequency used: Tick by tick.

- Data Source: NSE, India
AT intensity between 2009-13

Start of
Pre co-lo co-lo Post co-lo

2009 2010 2011 2012 2013
10 20 30 40 50 60 70
AT Intensity (%)
Concentration of AT across stocks
Market quality measures

- **Liquidity**
  1. **Transactions costs**
     1.1 QSPREAD (in %): \((\text{Best Ask Price} - \text{Best Sell Price}) \times 100 / \text{Mid-quote price}\).
     1.2 IC (%): at the transaction size of Rs 25,000.
  2. **Depth**
     2.1 TOP1DEPTH (in Rs.): Rupee depth available at the best bid and ask prices.
     2.2 TOP5DEPTH (in Rs.): Cumulated Rupee depth available at top five best bid and ask prices.
     2.3 DEPTH (# of shares): Average of the outstanding buy side and sell side number of shares.
     2.4 |OIB| (in %): Difference in buy and sell side depth as a percentage of the total depth, on average.

- **Volatility**
  1. LRISK: Standard deviation of IC in five-minutes interval.
  2. RVOL: Standard deviation of five-minutes returns.

- **Efficiency**
  1. VR: Ratio of ten minutes variance of returns to five minute returns
Market quality measures

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Methodology

- Identify an exogenous event that affected AT intensity in the markets: co-location facilities.

- Two approaches:
  1. Comparative analysis of average levels of market quality variables in the LOW-AT and HIGH-AT period.
  2. Cross sectional analysis using fixed effects model (Model 1):

\[
\text{MKT-QUALITY}_{i,t} = \alpha_i + \beta_1 \text{AT-INTENSITY}_{i,t-1} + \beta_2 \text{COLO-DUMMY}_t + \epsilon_{i,t}
\]

where ‘t’ = 1…T indexes of five minute time intervals

\[
\text{COLO-DUMMY}_t = \begin{cases} 
1 & \text{if ‘t’ } \in \text{ Post co-lo period} \\
0 & \text{otherwise}
\end{cases}
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Threats to validity
How to control for the changes in macroeconomic conditions?

1. Regression based approach:

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\text{MKT-QUALITY}_{i,t} = \alpha_i + \beta_1 \text{CO-LO-DUMMY}_t + \beta_2 \text{AT-INTENSITY}_{i,t-1} + \beta_3 \text{NIFTY-VOL}_t + \epsilon_{i,t}
\]

where \(\text{NIFTY-VOL}_{i,t}\) is the variance of five-minute returns on the market index.

2. Matched sample approach:
   - Pick dates in the post co-lo period when market volatility matched the levels in the pre co-lo period.
   - Matched Sample: 41 dates in each period.
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Results
Comparing liquidity costs in the HIGH-AT & LOW-AT sample
Depth behavior in the HIGH-AT & LOW-AT period

![Graphs showing depth behavior in the HIGH-AT & LOW-AT period.](image)
.. and the volatility measures

![LRISK graph]

![RVOL graph]
Results: Effect of AT on market quality variables

\[ M1: \text{MKT-QUALITY}_{i,t} = \alpha_i + \beta_1 \text{AT-INTENSITY}_{i,t-1} + \beta_2 \text{CO-LO-DUMMY}_t + \epsilon_{i,t} \]

### Panel A: Transactions costs and Rupee depth

<table>
<thead>
<tr>
<th></th>
<th>QSPREAD</th>
<th>IC</th>
<th>TOP1DEPTH</th>
<th>TOP5DEPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT-INTENSITY</td>
<td>-0.01⁺</td>
<td>-0.01⁺</td>
<td>-0.09⁺</td>
<td>-0.17⁺</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.02)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>CO-LO-DUMMY</td>
<td>-0.01⁺</td>
<td>-0.01⁺</td>
<td>-0.81⁺</td>
<td>-0.46⁺</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Obs.</td>
<td>315,115</td>
<td>315,115</td>
<td>315,115</td>
<td>315,115</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.10</td>
<td>0.07</td>
<td>0.24</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Panel B: Depth and Volatility

|                | DEPTH   | \( |OIB| \) | LRISK   | RVOL    |
|----------------|---------|------|--------|--------|
| AT-INTENSITY   | 0.10⁺   | 4.54⁺| -0.001**| -5.15⁺ |
|                | (0.01)  | (0.49)| (0.000) | (1.12) |
| CO-LO-DUMMY    | 0.35⁺   | -30.18⁺| -0.01⁺ | -46.40⁺ |
|                | (0.01)  | (0.96)| (0.00)  | (1.77) |
| \( R^2 \)      | 0.18    | 0.26 | 0.20    | 0.26    |
Dealing with threats to validity

**M1**: \( \text{MKT-QUALITY}_{i,t} = \alpha_i + \beta_1 \text{AT-INTENSITY}_{i,t-1} + \beta_2 \text{CO-LO-DUMMY}_t + \epsilon_{i,t} \)

**M4**: \( \text{MKT-QUALITY}_{i,t} = \alpha_i + \beta_1 \text{AT-INTENSITY}_{i,t-1} + \beta_2 \text{CO-LO-DUMMY}_t \\
+ \beta_3 \text{NIFTY-VOL}_t + \beta_4 \text{INTRADAY-DUMMY}_t + \beta_5 \text{LTP}_{i,t} + \epsilon_{i,t} \)

<table>
<thead>
<tr>
<th>Value of ( \hat{\beta}_1 )</th>
<th>One month sample</th>
<th>Matched sample</th>
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<tr>
<td><strong>QSPREAD</strong></td>
<td>-0.01(^+)</td>
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<tr>
<td><strong>DEPTH</strong></td>
<td>0.10(^+)</td>
<td>0.12(^+)</td>
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<tr>
<td><strong>OIB</strong></td>
<td>4.54(^+)</td>
<td>4.91(^+)</td>
</tr>
<tr>
<td><strong>RVOL</strong></td>
<td>-5.15(^+)</td>
<td>-2.56(^+)</td>
</tr>
<tr>
<td><strong>LRISK</strong></td>
<td>-0.001(^{**})</td>
<td>-0.00</td>
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Conclusion

- The world has shifted from manual to computer-supported trading in a stunningly short time
- A major new phenomenon that requires analysis
- All the regulators of the world are interested
- Numerous existing papers, but three flaws: (a) Fragmented microstructure (b) Endogenous adoption of AT and (c) Lack of underlying data infrastructure.
- Our research design solves these three problems, and reports on one of the biggest exchanges of the world by order intensity.
- Matching-based strategy that controls for changes in macroeconomic conditions.
- Main result: AT is good for market quality but depth visible goes down.
Thank you

Comments / Questions?

http://www.ifrogs.org/