Tick Size Constraints, Market Structure and Liquidity

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What Are Tick Size Constraints

Standard Walrasian equilibrium
- Continuous price

Reality
- Discrete prices
- SEC rule 612: 1 penny tick size
  - Prohibits stock exchanges from displaying orders in an increment smaller than $0.01 if the quotation, order, or indication of interest is priced equal to or greater than $1.00 per share.
  - No sub-penny pricing
Relative Tick Size: Example

<table>
<thead>
<tr>
<th></th>
<th>Citigroup</th>
<th>HSBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$3.3</td>
<td>$59</td>
</tr>
<tr>
<td>Relative Tick Size</td>
<td>30 basis points</td>
<td>1.69 basis points</td>
</tr>
</tbody>
</table>

![Bar graph showing relative tick size comparison between Citigroup and HSBC](image-url)
Average spread sizes in cents for S&P 500 stocks

Source: Credit Suisse
Economic Consequences of Price Constraints

Queuing: first come, first served
Example: High-frequency trading
Speed allocates resources

Side payment
Example: Taker/maker market
Liquidity provider pays a fee to make the market
Relative Tick Size and Speed

HFT: 😊  Non-HFT: 😞

$100.04 😊
$100.03 😞
$100.02 😞
$100.01 😞
$100.00 😊

$50.00
$100.00
$100.01
$100.02
$100.03
“It was not obvious to Brad why some exchanges paid you to be a taker and charged you to be a maker, while others charged you to be a taker and paid you to be a maker. No one he asked could explain it, either. To Brad this all just seemed bizarre and unnecessarily complicated—and it raised all sorts of questions. “Why would you pay anyone to be a taker? I mean, who is willing to pay to make a market? Why would anyone do that?”

— Michael Lewis: Flash Boys
Taker/maker Market

Large Relative Tick Size

Taker/maker market

Give me a fee, I will let you make the market in the taker/maker market!
Contribution

Two existing channels (Biais and Foucault, 2014)

- Competition channel
  - Speed allows HFTers to provide better price of liquidity
- Information channel
  - Fast access to information (Biais, Foucault and Moinas, 2013)
  - Fast react to public information (Budish, Cramton and Shim, 2013)

This paper: tick size constraints channel

- Speed allows HFT establish time priority when price competition is more constrained
- Non-informal drivers of HFT
- Taker/maker market
Main Hypothesis

• Larger relative tick size causes more HFT liquidity provision and taker/maker market
  – Low priced stocks attract more HFT liquidity providers
  – Low priced stocks have larger mark share in taker/maker market

• Challenge: endogeneity (Roberts and Whited, 2012)
  – Omitted variables
    • Fail to control variables correlated with price as well as HFT market making
  – Reverse causality
    • HFT liquidity provision reduces nominal price
Identification Strategy

• Double sorting
  – Nominal share price is exogenous after controlling for market cap (Benartzi, Michaely, Thaler and Weld, 2009)

• Regressions analysis

• Diff-in-diff regression of ETFs splits
  – Pilot: ETFs that split/reverse splits
  – Control: ETFs tracking the same index but are not treated
Computation: Two Supercomputers

Gordon
San Diego, California

Blacklight
Pittsburg, Pennsylvania
Tick size constraints encourage taker/maker market

Robustness check using diff in diff

Tick size constraints

HFT
Data: NASDAQ HFT Dataset for 120 Stocks

• Snapshots of limit order book
  – The depth at best price from HFT and non-HFT in each minute for 120 stocks in October, 2010

• Quote updates from HFT and non-HFT
  – February 22, 2010-Februray 26, 2010
  – Address the stale quotes issue

• Volume with HFT and Non-HFT as liquidity providers

• Limitation of the data
<table>
<thead>
<tr>
<th>Relative Tick Size</th>
<th>(1) HFT Only</th>
<th>(2) Non-HFT Only</th>
<th>(3) HFT &amp; Non-HFT Only</th>
<th>(4) Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large (Low Price)</td>
<td>1.60%</td>
<td>2.50%</td>
<td>95.90%</td>
<td>1.55</td>
</tr>
<tr>
<td>Large Cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium (Medium Price)</td>
<td>11.90%</td>
<td>18.60%</td>
<td>69.60%</td>
<td>1.57</td>
</tr>
<tr>
<td>Small (High Price)</td>
<td>16.80%</td>
<td>37.70%</td>
<td>45.50%</td>
<td>2.25</td>
</tr>
<tr>
<td>Middle Cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (Low Price)</td>
<td>18.00%</td>
<td>15.20%</td>
<td>66.80%</td>
<td>0.84</td>
</tr>
<tr>
<td>Medium (Medium Price)</td>
<td>20.00%</td>
<td>56.60%</td>
<td>23.40%</td>
<td>2.83</td>
</tr>
<tr>
<td>Small (High Price)</td>
<td>20.70%</td>
<td>63.70%</td>
<td>15.70%</td>
<td>3.08</td>
</tr>
<tr>
<td>Small Cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (Low Price)</td>
<td>11.30%</td>
<td>54.70%</td>
<td>34.10%</td>
<td>4.86</td>
</tr>
<tr>
<td>Medium (Medium Price)</td>
<td>20.20%</td>
<td>55.80%</td>
<td>24.00%</td>
<td>2.77</td>
</tr>
<tr>
<td>Small (High Price)</td>
<td>18.60%</td>
<td>70.70%</td>
<td>10.70%</td>
<td>3.8</td>
</tr>
<tr>
<td>Total</td>
<td>15.40%</td>
<td>41.70%</td>
<td>42.90%</td>
<td>2.62</td>
</tr>
<tr>
<td>Firm Size</td>
<td>Relative Tick Size</td>
<td>HFT_improve</td>
<td>Nonhft_improve</td>
<td>Ratio</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>Large</td>
<td>Large</td>
<td>0.72%</td>
<td>0.16%</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>6.72%</td>
<td>2.39%</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>6.97%</td>
<td>9.25%</td>
<td>1.33</td>
</tr>
<tr>
<td>Medium</td>
<td>Large</td>
<td>3.97%</td>
<td>3.97%</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>9.33%</td>
<td>15.63%</td>
<td>1.68</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>8.86%</td>
<td>19.94%</td>
<td>2.25</td>
</tr>
<tr>
<td>Small</td>
<td>Large</td>
<td>5.29%</td>
<td>15.87%</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>7.37%</td>
<td>19.29%</td>
<td>2.62</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td>10.05%</td>
<td>24.01%</td>
<td>2.39</td>
</tr>
</tbody>
</table>
Roadmap

Tick size constraints encourage taker/maker market

Diff in diff test

Tick size constraints encourage HFT
## Identification Strategy: Twin Trading Platforms Offered by Direct Edge

<table>
<thead>
<tr>
<th>EDGA: Taker/maker</th>
<th>EDGX: Maker/taker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liquidity provider</strong></td>
<td><strong>Liquidity provider</strong></td>
</tr>
<tr>
<td>• Pays 0.025 cents</td>
<td>• Gets 0.25 cent rebate</td>
</tr>
<tr>
<td><strong>Liquidity demander</strong></td>
<td><strong>Liquidity demander</strong></td>
</tr>
<tr>
<td>• Gets 0.015 cent</td>
<td>• Pays 0.3 cents</td>
</tr>
</tbody>
</table>

Real vs. Nominal: 
- Real: 
  - EDGA: Taker/maker
  - EDGX: Maker/taker
- Nominal: 
  - EDGA: Taker/maker
  - EDGX: Maker/taker
Two Results Supporting Tick Size Constraints Story

Cross-sectional variation

- Low price stocks: higher tick size constraint
- Taker/maker is more active for low priced stocks

Cross venue variation

- HFTers are more active in maker/taker market
  - Be paid to provide liquidity
- Non-HFTers are more likely to pay for providing liquidity
  - A way to jump ahead of the queue
## Importance of Taker/maker Market

Taker/maker is very active for low-priced large stocks

- Higher tick size constraints
- Taker/maker fee is a way to bypass the constraints

<table>
<thead>
<tr>
<th>EDGA Volume / (EDGX Volume + EDGA Volume)</th>
<th>High Relative Tick Size (Low Price)</th>
<th>Medium Relative Tick Size (Medium Price)</th>
<th>Small Relative Tick Size (High Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Cap</td>
<td>64.28%</td>
<td>54.57%</td>
<td>28.98%</td>
</tr>
<tr>
<td>Medium Cap</td>
<td>55.94%</td>
<td>40.95%</td>
<td>38.33%</td>
</tr>
<tr>
<td>Small Cap</td>
<td>43.56%</td>
<td>29.79%</td>
<td>24.53%</td>
</tr>
</tbody>
</table>
(Imperfect) Separating Equilibrium

Maker/taker market
EDGX
Paid to provide liquidity

Taker/maker market
EDGA
Pay to provide liquidity
Two Measures of HFT Activity from TAQ Data

Quote-to-trade ratio

– Angel, Harris and Spatt (2010)

Dollar volume per message times (-1)


These two ratios increase as ratio of HFTers relative to non-HFTers increases

– HFTers cancel lots of orders and generate lots of messages
Differences in HFT across Trading Platforms

$$\text{HFT}_{ijt} = u_i + \gamma_t + \alpha + \beta_1 \text{EDGA}_{ijt} + \beta_2 \text{EDGA}_{ijt} \times \text{Prc}_i + \beta_3 \text{EDGA}_{ijt} \times \log \text{mktcap}_i + \epsilon_{ijt}$$

- i: firm
- t: time
- j: EDGA or EDGX
- EDGA: dummy variable
- Difference in HFT activity between EDGA and EDGX
  - $\beta_1$: average difference
  - $\beta_2$: interaction with price
  - $\beta_3$: interaction with market cap
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Quote to trade ratio</th>
<th>(2) Volume to message ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDGA</td>
<td>-9.350***</td>
<td>-0.690***</td>
</tr>
<tr>
<td></td>
<td>(1.347)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>EDGA*pirc</td>
<td>.0537***</td>
<td>.1353***</td>
</tr>
<tr>
<td></td>
<td>(.0115)</td>
<td>(.014)</td>
</tr>
<tr>
<td>EDGA*logmktcap</td>
<td>.8728</td>
<td>-.2035**</td>
</tr>
<tr>
<td></td>
<td>(.5985)</td>
<td>(.092)</td>
</tr>
<tr>
<td>Constant</td>
<td>30.63***</td>
<td>-4.95***</td>
</tr>
<tr>
<td></td>
<td>(2.809)</td>
<td>(.4082)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.227</td>
<td>0.784</td>
</tr>
<tr>
<td>Observations</td>
<td>4888</td>
<td>4888</td>
</tr>
<tr>
<td>Time effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Firm effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Relative HFT Activity

Median firm

Stock price

EDGX

EDGA
The Role of Price (Relative Tick Size)

When tick size constraint is binding

I can undercut!

I can go to taker/maker market!

Non-HFTer is more likely to go to taker/maker market for low-priced stocks

I want to get higher priority! What should I do?
Roadmap

Tick size constraints encourage taker/maker market

Diff in diff test

Tick size constraints encourage HFT
Diff-in-Diff Regression

• Leveraged ETFs
  – ETFs amplifying the return of the underlying index
  – Appear in pairs: Bear and Bull
  – Dow Jones 30
    • UDOW +300%
    • SDOW-300%

• Same issuance price

• Splits/reverse splits after large price divergence
  • Treatment : ETFs split/reverse split
  • Control: ETFs do not split/reverse split
Regression Specification

\[ y_{i,t,j} = u_{i,t} + \gamma_{j} + \rho \times D_{i,t,j} + \theta \times \text{return}_{i,t,j} + \epsilon_{i,t,j} \]

- \[ y_{i,t,j} \]
  - Proxy for HFT activity: Hasbrouck and Saar (2013)
  - Market liquidity measure: spread and depth

- \[ u_{i,t} \] is the index by time fixed effect

- \[ \gamma_{j} \] is the ETF fixed effect

- \[ D_{i,t,j} \] : Treatment dummy
  - Treatment group: 1 after splits and 0 before splits
  - Control group: always 0
Without Tick Size Constraints

Splits
- Price ↓
- Normal spread ↓

Reverse splits
- Price ↑
- Normal spread ↑

Proportional spread should not change
- Cost to trade the same dollar amount should not be affected

HFT activity should not change because of fundamentals
## Reverse Split

<table>
<thead>
<tr>
<th></th>
<th>(1) Qtspd (in cent)</th>
<th>(2) pQtspd (in bps)</th>
<th>(3) Depth1 (in mn)</th>
<th>(4) RunsInProc (in .1sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy&lt;sub&gt;treatment&lt;/sub&gt;</td>
<td>1.175***</td>
<td>-2.608***</td>
<td>-0.321***</td>
<td>-5.348***</td>
</tr>
<tr>
<td></td>
<td>(8.41)</td>
<td>(-13.48)</td>
<td>(-6.02)</td>
<td>(-17.08)</td>
</tr>
<tr>
<td>return</td>
<td>-1.648</td>
<td>-3.622**</td>
<td>0.878**</td>
<td>-3.028</td>
</tr>
<tr>
<td></td>
<td>(-1.56)</td>
<td>(-2.48)</td>
<td>(2.19)</td>
<td>(-1.28)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.190***</td>
<td>9.260***</td>
<td>0.547***</td>
<td>10.343***</td>
</tr>
<tr>
<td></td>
<td>(8.79)</td>
<td>(18.42)</td>
<td>(3.95)</td>
<td>(12.71)</td>
</tr>
<tr>
<td>R²</td>
<td>0.834</td>
<td>0.883</td>
<td>0.787</td>
<td>0.797</td>
</tr>
<tr>
<td>N</td>
<td>2559</td>
<td>2559</td>
<td>2559</td>
<td>2559</td>
</tr>
<tr>
<td>Index*time FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>ETF FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
Reverse Split

HFT: 😊  Non-HFT: 😕

$50.02

$50.01

$50.00
Conclusion

HFTers are more active with large relative tick size
- Price competition is more constrained

Non-informational channel of speed competition
- Splits/reverse splits do not increase/decrease the amount of information of an ETF relative to its pair
  • But HFT activity change
- HFT provides more liquidity for stocks with less information asymmetry and large relative tick size

Taker/maker market is another way to bypass tick size constraints
Policy Implications on HFT

• Debates on HFT and Marker/taker fee
  – Whether to pursue additional regulation
  – This paper: HFT can be consequence of existing regulation

• Tick size
  – A recently announced pilot program to increase tick size for less liquid stocks
  – Argument: wider tick size increase liquidity and controls HFT and finally increase IPO
  – We show the opposite
  – SEC should consider pilot program to decrease tick size for liquid stocks
Policy Implications: Maker/taker fee

• Agency issues on maker/taker fee
  – Battalio, Corwin and Jennings (2014); Angel, Harris and Spatt (2010 and 2013)
    • Broker route orders based on the fee but not execution quality

• Solution
  – Remove the fee
    • Solve the agency issue by effectively increasing tick size
  – Ask brokers to rebate the fee to customers
  – Reduce tick size (this paper)