Tick Size Constraints, High Frequency Trading and Liquidity

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What Are Tick Size Constraints

Standard Walrasian equilibrium

– Continuous price

Reality

– Discrete prices
– SEC regulation prohibits sub-penny pricing

SEC 612 (Minimum Pricing Increment) 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.
### Background

<table>
<thead>
<tr>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100.04</td>
<td>Tick Size: minimum price increment (1 cent here)</td>
</tr>
<tr>
<td>$100.03</td>
<td>Relative Tick Size: Tick Size / Price (about 1 bps here)</td>
</tr>
<tr>
<td>$100.02</td>
<td></td>
</tr>
<tr>
<td>$100.01</td>
<td></td>
</tr>
<tr>
<td>$100.00</td>
<td></td>
</tr>
</tbody>
</table>
Spread: Best Ask - Best Bid
(2 cents here)

Proportional Spread: Spread/Price
(about 2 bps here)
Background

**Liquidity provision:** limit orders waiting for incoming market orders

**Dollar Depth:** Dollar value of depth on each price
Binding Tick Size Constraints

Average spread sizes in cents for S&P 500 stocks

- 1 cent: 50%
- 2 cents: 33%
- 3 cents: 8%
- 4 cents: 5%
- 5 cents: 2%
- Stocks priced <= $100
Price Floor

Tick size = 1 penny

Price of Liquidity

Supply

Demand

Surplus

Price floor

Quantity of Liquidity
Economic Consequences of Price Floor

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

Two existing channels (Biais and Foucault, 2014)

– Competition channel
  • Speed allows HFTers to provide better price of liquidity
  • Avoid pick off risk (Hendershott, Jones and Menkveld, 2011)
  • Better management of inventory (Brogaard et al, 2013)

– 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

– Non-HFTers provide better price
– Non-informal drivers of HFT
# Relative Tick Size: Example

<table>
<thead>
<tr>
<th></th>
<th>Citigroup</th>
<th>HSBC</th>
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<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>

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![Bar chart comparing Citigroup and HSBC prices](chart.png)
Example

HFTer willing to quote proportional spread of 30 basis points

Non-HFTer willing to quote proportional spread of 15 basis points
Relative Tick Size: 30 BPS

has **time** priority over
(when they quote at the same price)
Relative Tick Size: 15 BPS

- A is willing to quote at 15 BPS
- B has price priority over
- B is willing to quote at 30 BPS

Bid asks are relative in tick size.
Main Hypothesis

• Larger relative tick size causes more HFT liquidity provision
  – Low priced stocks attract more HFT liquidity providers

• Challenge: endogeneity
  – 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

• Twin ETFs: ETFs tracking the same index

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

Twin ETFs

Multivariate regression

R

Diff-in-diff regression of ETFs splits
## Who Quotes the Best Price?

<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</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large Cap</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>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><strong>Middle Cap</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Large (Low Price)</td>
<td>18.00%</td>
<td>15.20%</td>
<td>66.80%</td>
<td>0.84</td>
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<td>Medium (Medium Price)</td>
<td>20.00%</td>
<td>56.60%</td>
<td>23.40%</td>
<td>2.83</td>
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<tr>
<td>Small (High Price)</td>
<td>20.70%</td>
<td>63.70%</td>
<td>15.70%</td>
<td>3.08</td>
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<tr>
<td><strong>Small Cap</strong></td>
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<tr>
<td>Large (Low Price)</td>
<td>11.30%</td>
<td>54.70%</td>
<td>34.10%</td>
<td>4.86</td>
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<td>Medium (Medium Price)</td>
<td>20.20%</td>
<td>55.80%</td>
<td>24.00%</td>
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<td>Small (High Price)</td>
<td>18.60%</td>
<td>70.70%</td>
<td>10.70%</td>
<td>3.8</td>
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<tr>
<td><strong>Total</strong></td>
<td>15.40%</td>
<td>41.70%</td>
<td>42.90%</td>
<td>2.62</td>
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</table>
Tick Size Constraints and Volume

Low-priced stocks
- High tick size constraints
- Higher probability that HFTers and non-HFTers will quote same price
- HFTers can establish time priority more easily

Prediction
- Percentage of volume with HFTers as liquidity providers increases in relative tick size
Double sorting

Multivariate regression

Control for observable variables

Twin ETFs

Diff-in-diff regression of ETFs splits
Omitted Variable Bias

Variables correlated with both
  – Nominal prices (relative tick size)
  – HFT market marking

Search for control variables affecting at least one of them
  – Though most of them have been disqualified by Benartzi, Michaely, Thaler and Weld (2009)
Five Literatures on Nominal Prices

Marketability hypothesis
   – lower price appeals to individual investors

Optimal tick size hypothesis
   – firms choose optimal relative tick size through split

Signaling hypothesis
   – Firms use stock splits to signal good news

Catering hypothesis

Low price predicts distress risk
Factors Affecting HFT Market Marking

Probability of informed trading (PIN)
   – Control for information asymmetry

Volatility and turnover
   – Hendershott, Jones, and Menkveld (2011)

Past Returns
## HFT Liquidity Provision

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>HFTdepth (in percentage)</th>
<th>(1)</th>
<th>(2)</th>
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<td>Industry*time FE</td>
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<td>Y</td>
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</tr>
</tbody>
</table>
Double sorting

Multivariate regression

Twin ETFs

Control for observables and unobservable variables that affects HFT through fundamentals

Diff-in-diff regression of ETFs splits
Twin ETFs

ETFs tracking the same index

- Eg. Both SPY and iShares tracking S&P500
- Different relative tick size

• Regression Specification

  \[ y_{i,t,j} = u_{i,t} + \beta \times \text{tick}_{relative} \downarrow i,t,j + \rho \times \log \text{mktcap}_{i,t,j} + \epsilon_{i,t,j} \]

- \( y_{i,t,j} \)
  1. Liquidity (spread and depth)
  2. HFT market making
     - \textit{RunInProcess} (Hasbrouck and Saar (2013))

- \( u_{i,t} \) is the index by time fixed effect

  • Control for the common fundamentals of twin ETFs
Without Tick Size Constraints

Liquidity

– Lower priced ETF: lower nominal spread
– Higher priced ETF: higher nominal spread
– Proportional spread: the same
  • Same cost to trade fixed dollar amount

HFT activity should be the same

– Common fundamentals
## Twin ETFs

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<tbody>
<tr>
<td><strong>Qtspd</strong></td>
<td>(in cent)</td>
<td><strong>pQtspd</strong> (in bps)</td>
<td><strong>Depth1</strong> (in mn)</td>
<td><strong>RunsInProc</strong> (in .1sec)</td>
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<td><strong>tick_{relative}</strong></td>
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<td>(7.88)</td>
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<tr>
<td><strong>Index*time FE</strong></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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</tbody>
</table>
Double sorting

Multivariate regression

Twin ETFs splits:

Exogenous shock to relative tick size

Diff-in-diff regression of ETFs splits:
**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

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

\( u_{i,t} \) 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
## Split

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<tr>
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<th>Qtspd</th>
<th>pQtspd</th>
<th>Depth1</th>
<th>RunsInProc</th>
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<tbody>
<tr>
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<td>(in cent)</td>
<td>(in bps)</td>
<td>(in mn)</td>
<td>(in .1sec)</td>
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<td>(3.42)</td>
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<td>-6.698**</td>
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<td>ETF FE</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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</table>
Split

HFT: 😊  Non-HFT: 😞

$100.04 😊😊😊😊

$100.03 😊😊😊😊😊

$100.02 😊😊😊😊😊

$100.01 😊😊😊😊😊

$100.00 😊😊😊😊😊

$50.00

$50.01

$50.02

$50.015
## Reverse Split

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<th>Depth1 (in mn)</th>
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<td>return</td>
<td>-1.648 (-1.56)</td>
<td>-3.622** (-2.48)</td>
<td>0.878** (2.19)</td>
<td>-3.028 (-1.28)</td>
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<tr>
<td>Constant</td>
<td><strong>3.190</strong>* (8.79)</td>
<td><strong>9.260</strong>* (18.42)</td>
<td><strong>0.547</strong>* (3.95)</td>
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<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

$100.04

$100.03

$100.02

$100.01

$100.00
Conclusion

Non-HFTers provide better price of liquidity
  – 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
Policy Implication

• Debates on HFT
  – Whether to pursue additional regulation on HFT
  – This paper: HFT can be consequence of existing regulation
  – Deregulation instead of more 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