Shall We Haggle in Pennies at the Speed of Light or in Nickels in the Dark? How Minimum Price Variation Regulates High Frequency Trading and Dark Liquidity

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UC Berkeley School of Law

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UC Berkeley School of Law
Motivation

- Recent concerns with the U.S. system of market structure have focused on proposed reforms to tick size regulation (i.e., the price at which stocks are traded):

  
  **April 2010 Request for SEC Rule-making by BATS Exchange, Inc., NASDAQ OMX Group, Inc., and NYSE Euronext, Inc**

  - **Concern:** Displayed quote is “artificially wide” for certain lower priced, liquid securities, causing a detrimental impact to the public price discovery process.
  
  - **Recommendation:** Permit quoting in ½ cent ($0.005) increments for securities trading between $1.00 and $20.00 per share.

  
  **Section 106 of the Jumpstart Our Business and Start-ups Act of 2012 + SEC Advisory Committee on Small and Emerging Businesses (2013)**

  - **Concern:** Transition from fractional to penny-based pricing of securities in 2000 destroyed the profitability of market-making, harming market support for smaller issuers.
  
  - **Recommendation:** Increase the minimum price variation (MPV) from $0.01 to $0.05 or even $0.1 for securities having low liquidity.
Background on U.S. Equity Trading Environment

Investor

- Sell 1,000 shares of ABC

Broker

- Buy 1,000 shares of ABC

Liquidity Providers

- NASDAQ
  - Bid: 1,000 @ $9 7/8
  - Ask: 1,000 @ $10 3/8
- BSE
  - Bid: 1,000 @ $9 7/8
  - Ask: 1,000 @ $10 3/8
- CSE
  - Bid: 1,000 @ $9 1/2
  - Ask: 1,000 @ $10 1/2
- NBBO
  - Bid: 1,000 @ $10
  - Ask: 1,000 @ $10 1/8
- Direct Edge
  - Bid: 1,000 @ $9 3/8
  - Ask: 1,000 @ $10 1/2

American Stock Exchange

- Bid: 1,000 @ $9 7/8
- Ask: 1,000 @ $10 3/8

NYSE

- Bid: 1,000 @ $9 1/2
- Ask: 1,000 @ $10 1/2

Cincinnati Stock Exchange

- Bid: 1,000 @ $10
- Ask: 1,000 @ $10 1/8
Background on U.S. Equity Trading Environment

**NBBO**
Bid: 1,000 @$10.05
Ask: 1,000 @ $10.09

**NYSE**
Bid: 1,000 @$9.55
Ask: 1,000 @ $10.5

**Boston Stock Exchange**
Bid: 1,000 @$9.8
Ask: 1,000 @ $10.4

**American Stock Exchange**
Bid: 1,000 @$9.82
Ask: 1,000 @ $10.42

**Cincinnati Stock Exchange**
Bid: 1,000 @$10.05
Ask: 1,000 @ $10.09

**Direct Edge**
Bid: 1,000 @$9.90
Ask: 1,000 @ $10.46

**Nasdaq**
Bid: 1,000 @$9.90
Ask: 1,000 @ $10.45

**Internalizer/Dark Pool (Citadel, Knight Capital)**
Buys 1,000 @$10.0899
Sell 1,000 @ $10.0501

Sell 1,000 shares of ABC
Buy 1,000 shares of ABC

Liquidity Providers
Background on U.S. Equity Trading Environment

**NBBO**
Bid: 1,000 @$10.05  
Ask: 1,000 @$10.09

**NYSE**
Bid: 1,000 @$9.55  
Ask: 1,000 @$10.09

**Boston Stock Exchange**
Bid: 1,000 @$9.8  
Ask: 1,000 @$10.4

**American Stock Exchange**
Bid: 1,000 @$9.82  
Ask: 1,000 @$10.42

**Cincinnati Stock Exchange**
Bid: 1,000 @$10.05  
Ask: 1,000 @$10.09

**Direct Edge**
Bid: 1,000 @$9.9  
Ask: 1,000 @$10.46

**Nasdaq**
Bid: 1,000 @$9.9  
Ask: 1,000 @$10.45

**Internalizer/Dark Pool** (Citadel, Knight Capital)

**Liquidity Providers**

**Sell 1,000 shares of ABC**

**Buy 1,000 shares of ABC**

**Pays access fee**

**Rebate $$**
Research Question and Hypotheses

- Central Research Question:
  - What would be the consequences on market structure of either (a) increasing tick sizes to more than a penny or (b) decreasing tick sizes further to permit subpenny quoting?

- Hypotheses:
  - Increasing tick sizes should result in:
    - More BD internalization and dark trading but less High Frequency Trading (HFT) on public (i.e., exchange/ECN) order books.
    - Wider quoted spreads
    - Greater inside depth
  
  - Decreasing tick sizes should result in:
    - Less BD internalization and dark trading but more HFT on public order books
    - Narrower quoted spreads
    - Less inside depth
Research Design

- Regression Discontinuity Framework:
  - We exploit the fact that while Rule 612 of Reg NMS requires an MPV of $0.01 for orders, subpenny orders are permitted for orders priced less than $1.00 per share (the “Subpenny Rule”).

![Graph showing trading interest vs. stock price per share between $0.99 and $1.01.](image-url)
Research Design

- Regression Discontinuity Framework:
  - We exploit the fact that while Rule 612 of Reg NMS requires an MPV of $0.01 for orders, subpenny orders are permitted for orders priced less than $1.00 per share (the “Subpenny Rule”).

```
Stock Price Per Share

<table>
<thead>
<tr>
<th>Penny Price Increment</th>
</tr>
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<tbody>
<tr>
<td>$0.99</td>
</tr>
<tr>
<td>$1.00</td>
</tr>
<tr>
<td>$1.01</td>
</tr>
</tbody>
</table>

Trading interest

- at $.99
- at $1.00
- at $1.01
```
Data

- NYSE Trade and Quote Data for 2011 (~7,083 securities)
- Focus on quotations/trades in securities that had at least one trade below $2.00 per share in 2011
  - 974 securities issued by 962 firms
    - Generated ~ 271 million trades and 3 billion updates of exchanges’ BBOs
  - Financial/accounting data pulled from CapitalIQ
### Sample Firms vs. CRSP Firms

#### Table 2: Sample Description and Sample Selection Comparison

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample Firms</th>
<th>Non-Sample Firms</th>
<th>All CRSP Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td><strong>Industrial Classification:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture, Forestry, And Fishing</td>
<td>4</td>
<td>0.4%</td>
<td>15</td>
</tr>
<tr>
<td>Mining</td>
<td>75</td>
<td>7.8%</td>
<td>278</td>
</tr>
<tr>
<td>Construction</td>
<td>10</td>
<td>1.0%</td>
<td>39</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>435</td>
<td>45.4%</td>
<td>1,498</td>
</tr>
<tr>
<td>Transportation, Communications, Electric, Gas, And Sanitary Services</td>
<td>63</td>
<td>6.6%</td>
<td>429</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>20</td>
<td>2.1%</td>
<td>107</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>33</td>
<td>3.4%</td>
<td>223</td>
</tr>
<tr>
<td>Finance, Insurance, And Real Estate Services</td>
<td>162</td>
<td>16.9%</td>
<td>2,802</td>
</tr>
<tr>
<td>Services</td>
<td>156</td>
<td>16.3%</td>
<td>639</td>
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<tr>
<td>Public Administration</td>
<td>1</td>
<td>0.1%</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total Non-Financial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign. Incorporation</td>
<td>159</td>
<td>20.0%</td>
<td>605</td>
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<tr>
<td>Involuntary Delistings:</td>
<td>99</td>
<td>10.3%</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: 797 Non-Financial, 159 Foreign. Incorporation, 99 Involuntary Delistings.
### Sample Firms vs. CRSP Firms

**Table 2: Sample Description and Sample Selection Comparison**

| Variable                  | Sample Firms | | | | | Non-Sample Firms | | | | | All CRSP Firms | | | |
|---------------------------|--------------|--------------|--------------|--------------|--------------|-----------------|--------------|--------------|--------------|-----------------|--------------|--------------|--------------|
|                           | Mean [Median] | (SE)         | Mean [Median] | (SE)         | Mean [Median] | (SE)           |
| Market Cap ($ millions)   | 916.91 [65.36] | (390.75)     | 108,688.60 [481.40] | (42,467.84) | 93,162.28 [349.82] | (36,352.25) |
| Total Assets              | 3,300.12 [89.51] | (1185.83)   | 448,210.10 [818.32] | (119,637.70 | 375,846.10 [609.63] | (100,200.20 |
| ROE                       | -0.63 [-0.15] | (0.13)       | 0.14 [0.09]    | (0.05)       | 0.01 [0.08]   | (0.05)        |
| ROA                       | -0.09 [-0.03] | (0.01)       | 0.03 [0.03]    | (0.00)       | 0.01 [0.03]   | (0.00)        |
| Sales Growth              | 2.08 [0.08]   | (0.88)       | 6.22 [0.10]    | (5.75)       | 5.60 [0.10]   | (4.89)        |
| Leverage                  | 0.31 [0.17]   | (0.04)       | 0.26 [0.19]    | (0.01)       | 0.27 [0.19]   | (0.01)        |
| Public Float              | 0.68 [0.73]   | (0.01)       | 0.79 [0.87]    | (0.00)       | 0.77 [0.84]   | (0.00)        |
| Volatility                | 0.68 [0.62]   | (0.01)       | 0.34 [0.32]    | (0.00)       | 0.39 [0.35]   | (0.00)        |
| Daily Trading Volume      | 0.64 [0.08]   | (0.13)       | 1.67 [0.15]    | (0.13)       | 1.52 [0.14]   | (0.11)        |
| Tobins q                  | 2.13 [1.22]   | (0.13)       | 2.68 [1.22]    | (0.58)       | 2.59 [1.22]   | (0.48)        |
| Market-to-Book            | 1.59 [1.20]   | (0.77)       | 3.09 [1.48]    | (2.03)       | 2.84 [1.44]   | (1.70)        |
Examination of Treatment Effect: Incidence of Subpenny Orders Above & Below $1.00/Share

Figure 1(a): Incidence of Sub-Penny Bids in 2011
National Best Bids Priced Less Than $2.00/share

% of Orders Made in Sub-Pennies

Two-Decimal Bid Price ($)

Average Subpenny Rate
Fit, -.208 (.034)
Examination of Treatment Effect: Incidence of Subpenny Orders Above & Below $1.00/Share

Figure 1(b): Incidence of Sub-Penny Offers in 2011
National Best Offers Priced Less Than $2.00/share

- Average Subpenny Rate
- Fit, -.219 (.05)
## 2011 Trading of Sample Securities by Venue:

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Number of trades</th>
<th>% of Total 2011 Trades</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Stock Exchange</td>
<td>1,794,016</td>
<td>2.08%</td>
</tr>
<tr>
<td>Boston Stock Exchange</td>
<td>3,416,200</td>
<td>3.96%</td>
</tr>
<tr>
<td>National (Cincinnati) Stock Exchange</td>
<td>2,265,754</td>
<td>2.62%</td>
</tr>
<tr>
<td><strong>FINRA Trade Reporting Facility</strong></td>
<td><strong>25,300,000</strong></td>
<td><strong>29.30%</strong></td>
</tr>
<tr>
<td>Direct Edge A Stock Exchange</td>
<td>5,146,107</td>
<td>5.96%</td>
</tr>
<tr>
<td>Direct Edge X Stock Exchange</td>
<td>7,633,681</td>
<td>8.84%</td>
</tr>
<tr>
<td>Chicago Stock Exchange</td>
<td>118,645</td>
<td>0.14%</td>
</tr>
<tr>
<td>New York Stock Exchange</td>
<td>2,053,069</td>
<td>2.38%</td>
</tr>
<tr>
<td>NYSE Arca SM</td>
<td>10,800,000</td>
<td>12.51%</td>
</tr>
<tr>
<td>NASDAQ Stock Exchange</td>
<td>10,600,000</td>
<td>12.27%</td>
</tr>
<tr>
<td>NASDAQ OMX Stock Exchange</td>
<td>4,072,291</td>
<td>4.72%</td>
</tr>
<tr>
<td>CBOE Stock Exchange</td>
<td>56,768</td>
<td>0.07%</td>
</tr>
<tr>
<td>NASDAQ OMX PSX Stock Exchange</td>
<td>610,878</td>
<td>0.71%</td>
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<tr>
<td>BATS Y-Exchange</td>
<td>3,241,613</td>
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</tr>
<tr>
<td>BATS Exchange</td>
<td>9,247,740</td>
<td>10.71%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>86,356,762</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>
Figure 3(a): Incidence of FINRA-Reported Trades in 2011 As a Function of Two-Decimal Trade Price
Figure 3(b): 2011 Trading Volume As a Function of Two-Decimal Trade Price

Fit, 9602.655000000001 (3452.51)
Measuring HFT: Rate of Updating of Exchanges’ Best Bid/Ask

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<th>symbol</th>
<th>date</th>
<th>time</th>
<th>bid</th>
<th>ofr</th>
<th>bidsiz</th>
<th>ofrsiz</th>
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<th>ex</th>
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<td>10:56:41</td>
<td>0.6541</td>
<td>0.6551</td>
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<td>25</td>
<td>12</td>
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<td>0.6551</td>
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<td>12</td>
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<td>0.6551</td>
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<td>12</td>
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<td>STEM</td>
<td>1-Jun-11</td>
<td>10:56:45</td>
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<td>0.6551</td>
<td>21</td>
<td>15</td>
<td>12</td>
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<tr>
<td>STEM</td>
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<td>10:56:45</td>
<td>0.655</td>
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<td>158</td>
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<td>STEM</td>
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<td>0.66</td>
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<td>3</td>
<td>12</td>
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<td>0.67</td>
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<td>3</td>
<td>12</td>
<td>Z</td>
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<td>1-Jun-11</td>
<td>10:56:50</td>
<td>0.655</td>
<td>0.67</td>
<td>2</td>
<td>3</td>
<td>12</td>
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<td>0.66</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>P</td>
</tr>
</tbody>
</table>

Updates per second:
- 10:56:41 → 1
- 10:56:42 → 2
- 10:56:43 → 0
- 10:56:44 → 1
- 10:56:45 → 5
- 10:56:46 → 0
- 10:56:47 → 0
- 10:56:48 → 0
- 10:56:49 → 0
- 10:56:50 → 9
Rate of Updating of Exchanges’ Best Bid/Ask: Average Above & Below $1.00/Share

Figure 4: BBO Updates Per Second As a Function of Two-Decimal Ask Price

Average Rate of BBO Updates
Fit, -.241 (.047)
Rate of Updating of Exchanges’ Best Bid/Ask: Incidence of Strategic Runs

Figure 5(a): Incidence of Security-Seconds Having At Least One BBO Update

Figure 5(b): Incidence of Security-Seconds Having At Least Fifty BBO Updates
Quoted Spreads Above & Below $1.00/Share

Figure 6: Quoted Spreads At the $1.00 Cut-off

Average spread as % of quote mid-point
Fit, .011 (.003)
Inside Depth Above & Below $1.00/Share

Figure 7(a): Quoted Bid Depth At the $1.00 Cut-off

Average quoted bid depth
Fit, 126.957 (16.387)

Figure 7(b): Quoted Ask Depth At the $1.00 Cut-off

Average quoted ask depth
Fit, 73.961 (17.31)
Robustness Check: Maker/Taker Fees at $1.00

Cincinnati Stock Exchange

Sell 1,000 ABC

Buy 1,000 ABC

Internalizer/Dark Pool (Citadel, Knight Capital)

Route to NBBO vs. Internalize?

What if access fees for subdollar stocks decline below the $1.00 cut-off?

Pays access fee?

NBBO
Bid: 1,000 @$10.05
Ask: 1,000 @ $10.09

Cincinnati Stock Exchange
Bid: 1,000 @$10.05
Ask: 1,000 @ $10.09

Pays access fee?
Robustness Check: Maker/Taker Fees at $1.00

- Fees and rebates as a percentage of a $10,000 trade of a stock valued at either $1.00 or $0.99 in 2011:

<table>
<thead>
<tr>
<th>Exchange:</th>
<th>Access Fee Charged to Liquidity Taker (% of $10,000 trade value)</th>
<th>Rebate Paid to Liquidity Provider (% of $10,000 trade value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price=$0.99</td>
<td>Price=$1.00</td>
</tr>
<tr>
<td>EDGA Exchange</td>
<td>0.00%</td>
<td>-0.06%</td>
</tr>
<tr>
<td>NYSE Arca</td>
<td>-0.10%</td>
<td>-0.30%</td>
</tr>
<tr>
<td>Nasdaq OMX BX</td>
<td>-0.10%</td>
<td>0.14%</td>
</tr>
<tr>
<td>BATS BZX</td>
<td>-0.10%</td>
<td>-0.29%</td>
</tr>
<tr>
<td>BATS BYX</td>
<td>-0.10%</td>
<td>0.02%</td>
</tr>
<tr>
<td>Nasdaq OMX PH</td>
<td>-0.20%</td>
<td>-0.25%</td>
</tr>
<tr>
<td>NYSE</td>
<td>-0.23%</td>
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</tr>
<tr>
<td>NYSE Amex</td>
<td>-0.25%</td>
<td>-0.28%</td>
</tr>
<tr>
<td>Nasdaq</td>
<td>-0.30%</td>
<td>-0.30%</td>
</tr>
<tr>
<td>EDGX Exchange</td>
<td>-0.30%</td>
<td>-0.30%</td>
</tr>
<tr>
<td>Chicago Stock Exchange</td>
<td>-0.30%</td>
<td>-0.30%</td>
</tr>
<tr>
<td>National Stock Exchange</td>
<td>-0.30%</td>
<td>-0.28%</td>
</tr>
</tbody>
</table>

Do exchanges that lower fees below the $1 cut-off see an uptick in subdollar trading?
Trading Volume at the $1.00 Cut-Off: 2010 vs. 2011

Figure 3(b): 2011 Trading Volume As a Function of Two-Decimal Trade Price

Figure 8(a): 2010 Trading Volume As a Function of Two-Decimal Trade Price
2010 Trading Volume for High Rebate Exchanges vs. FINRA

Chicago Board Options Exchange

NASDAQ OMX BX (Boston) Stock Exchange

Financial Industry Regulatory Authority (FINRA)

NYSE MKT (American) Stock Exchange
Conclusions:

- Overall, analysis of the 2011 trading data confirms each of the predicted effects of changing the MPV:
  - Compared to trades/orders priced under $1/share, trades/orders priced above $1/share reveal:
    - More BD internalization and dark trading but less HFT on public order books.
    - Wider quoted spreads
    - Greater inside depth
  - Conversely, trades/orders below $1.00 per share reveal:
    - Less BD internalization and dark trading but more HFT on public order books
    - Narrower quoted spreads
    - Less inside depth
  - Effects are robust to changes to maker/taker fees at $1.00
    - 2010 data also reveals incentive for market manipulation where maker rebate>quoted spread.
Conclusions:

- At their most general level, these results suggest increasing tick sizes will do little to bring back market support and analyst coverage for smaller companies.
  - Beneficiaries of larger spreads in the current trading environment are primarily BD internalizers, dark pools, and (possibly) stock exchanges, none of which can be expected to subsidize research for smaller issuers.
  - Such a change will have real trading costs in the form of higher spreads and longer cues at the inside bid.

- Conversely, decreasing tick sizes will result in less dark trading but greater HFT within public order books.
  - Such a change will lower quoted spreads with lower depth at inside bid.
  - Any such change should be accompanied by formal limitations on the amount of maker rebates to ensure they do not exceed MPV.