Every cloud has a silver lining: Fast trading, microwave connectivity and trading costs

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What we do, in a nutshell

A speed race in modern markets leads to speed differentials among traders.

What is the effect of these differentials on liquidity?

In our setting, the effect is negative.
Speed differentials: theory

- The effect of speed differentials on market quality may be positive or negative

  - Positive:
    - Hoffmann (2014)
    - Jovanovic and Menkved (2015)
    - Roșu (2015)
    - Aït-Sahalia and Sağlam (2017)

  - Negative:
    - Biais, Foucault and Moinas (2015)
    - Foucault, Hombert and Roșu (2016)
    - Menkveld and Zoican (2016)
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Speed differentials: empirics

- Liquidity suppliers try to stay on top of the latest technology to maintain a speed advantage
  - Brogaard, Hagströmer, Nordén and Riordan (2015)
Speed differentials: empirics

• Liquidity suppliers try to stay on top of the latest technology to maintain a speed advantage
  – Brogaard, Hagströmer, Nordén and Riordan (2015)

• Fast traders often provide liquidity
  – O’Hara (2015)
  – Yao and Ye (2015)
  – Brogaard, Hendershott and Riordan (2016)
  – Chordia, Green and Kottimukkalur (2016)

• Yet certain fast strategies are based on liquidity demand
  – Baron, Brogaard, Hagströmer and Kirilenko (2016)
  – Foucault, Kozhan and Tham (2016)
Information transmission between Chicago and New York
The race to zero in the Chicago-New York corridor

- Signal transmission speed:
  - Legacy fiber-optic cable: 8 ms
  - Spread Networks cable: 6.5 ms
  - Microwave networks: 4.5 ms
  - Speed of light: 4 ms
Microwave networks (MWNs)
MWN characteristics

• In 2011-2012, accessible by a small number of trading firms
  – limited number of FCC licenses
  – low bandwidth

• Fast, but not always reliable due to rain and snow fade
Equity reaction to futures trades

millisseconds after a futures trade

# trades, st. deviations

-5 0 5 10 15 20

1 2 3 4 5 6 7 8 9 10

low precipitation heavy precipitation

2 ms
What we find

• When speed differentials are eliminated due to precipitation
  – price impacts decline
  – trading costs decline, in part due to the emergence of latent liquidity
  – volatility declines
2013 democratization

• In early 2013, Quincy Data starts selling futures pricing information to everyone on a subscription basis – effectively democratizing information transmission

• The results of this move are similar to those of precipitation disruptions
Data and samples

• Trade and quote data for equities (DTAQ)
• Order book data for select futures from the CME
• Order book data from Nasdaq’s ITCH

• Precipitation data from the National Oceanic and Atmospheric Administration (NOAA)

• Sample period I: 2011-2012
• Sample period II: 2013-2014

• Sample: 100 ETFs
Precipitation along the MWN paths
(www.noaa.gov)
Data and samples

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- Sample period I: 2011-2012
- Sample period II: 2013-2014

- Sample: 100 ETFs
Price impacts

- Price impact are 30-40\% of effective spreads
  - Chakrabarty et al. (2016) find a similar share for a recent sample of equities
Price impacts during MWN disruptions

<table>
<thead>
<tr>
<th></th>
<th>Precip</th>
<th>Precip1</th>
<th>Precip2</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>-.010***</td>
<td>-.035***</td>
<td>-.047***</td>
</tr>
<tr>
<td></td>
<td>(.004)</td>
<td>(.012)</td>
<td>(.013)</td>
</tr>
</tbody>
</table>

$VIX$

$DEPVAR_{it} = \alpha_0 + \beta_1 PRECIP_t + \beta_2 VIX_t + \epsilon_{it}$

Price impacts decline by 0.047 standard deviations (or 7%) during heavy precipitation.

This effect is most pronounced in assets with narrow spreads.
Effective and realized spreads decline by, respectively, 7% and 5%.
## Order aggressiveness

### Panel A: NBBO match

<table>
<thead>
<tr>
<th></th>
<th>full sample</th>
<th>most constr.</th>
<th>least constr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRECIP</td>
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<td>(.006)</td>
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<tr>
<td>PRECIP1</td>
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<td>.095***</td>
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<td>(.011)</td>
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<tr>
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<td>.040***</td>
<td>.068***</td>
<td>.113***</td>
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<td>(.013)</td>
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</tbody>
</table>

### Panel B: NBBO match or improve

<table>
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<td>.008</td>
<td>.041***</td>
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<tr>
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<tr>
<td></td>
<td>.028***</td>
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<td>.107***</td>
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<td>(.010)</td>
<td>(.010)</td>
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<tr>
<td></td>
<td>.063***</td>
<td>.010</td>
<td>.126***</td>
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<tr>
<td></td>
<td>(.012)</td>
<td>(.015)</td>
<td>(.013)</td>
</tr>
</tbody>
</table>

Limit order aggressiveness increases by 2-3%
What happens to futures?

Hasbrouck (1995) methodology suggests that the futures market leads price discovery, CME information share is [0.64; 0.82]

Given that microwave bandwidth is a constrained resource, it should be used along the most profitable transfer channel: Chicago to New York

Indeed, price impacts do not change when the MWNs are disrupted

<table>
<thead>
<tr>
<th></th>
<th>Panel A: futures</th>
<th>Panel B: equities</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>(.031)</td>
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Event study: 2013 democratization

- In early 2013, McKay Brothers begins selling latest price information at both ends of the Chicago-New York corridor – this move effectively removes advantages of the fastest traders.

We find no precipitation effects in 2013-2014.

The Quincy offering is associated with declines in price impacts, effective and realized spreads, and volatility.

<table>
<thead>
<tr>
<th></th>
<th>PIMP</th>
<th>ESP</th>
<th>RSP</th>
<th>trades</th>
<th>volume</th>
<th>volatility</th>
<th>price</th>
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<td></td>
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<td>(.179)</td>
<td>(.184)</td>
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<td>(.135)</td>
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<tr>
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<td>.095</td>
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<tr>
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<td>(.178)</td>
<td>(.120)</td>
<td>(.123)</td>
<td>(.222)</td>
<td>(.129)</td>
</tr>
</tbody>
</table>
Conclusions

• In our setting, speed differentials lead to higher adverse selection, trading costs and volatility as the fastest traders choose to take liquidity

• Elimination of speed differentials not only reduces trading costs via the adverse selection channel, but also by strengthening liquidity supply

Thank you
Trading activity and volatility

The number of trades declines by 17.8%. Expectedly, this decline is observed only in the most constrained ETFs.

Volatility declines by 5.8%
## Robustness

<table>
<thead>
<tr>
<th></th>
<th>price impact</th>
<th>effective spread</th>
<th>realized spread</th>
<th>trades</th>
<th>volatility</th>
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<td>(.008)</td>
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<td>placebo area</td>
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<td>afternoon only</td>
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<td>-.063***</td>
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<td></td>
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<td>(.014)</td>
<td>(.010)</td>
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<tr>
<td>intraday FE</td>
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<td>-.028***</td>
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<td>-.141***</td>
</tr>
<tr>
<td></td>
<td>(.012)</td>
<td>(.012)</td>
<td>(.008)</td>
<td>(.021)</td>
<td>(.035)</td>
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Intraday patterns
A weather front
Behavioral explanation