

# Who Supplies Liquidity, and When?

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# Mini-Flash Crashes and Market Stability

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- Mini-flash crashes: Sharp price movements in one direction followed by quick reversion (Biais and Foucault, 2014)
- Mini-flash crashes occur about 12 times a day



# Amazon's Stock in a Mini-flash Crash on June 9, 2017

- 2:50:01 p.m.: \$960.55 per share
- 2:50:02 p.m.: \$930.00 per share
- 2:50:03 p.m.: \$953.07 per share

**AMAZON.COM (AMZN)** NAS

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♥ **976.17** USD **-34.10 (-3.38%)** 03:13:56 PM EDT '17

Prev. Close	1,010.27	Market Cap (USD)	478.57 B	Day Low	928.61	Day High	1,012.81	52 Week Low	682.31	52 Week High	1,038.50
Open	1,012.50	Volume (Qty.)	1,355,365								



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# Modern Electronic Markets

- Designated market makers disappear in most stock exchanges
- Everyone can supply liquidity
- No one has to supply liquidity
- **Who supplies liquidity, and when? Does high frequency trading (HFT) cause mini-flash crashes?**

# Literature on HFTs

- Two types of traders
  - ▶ High-frequency traders (HFTs): superfast computers
  - ▶ Everyone else (non-HFTs)
- Exogenous roles
  - ▶ HFTs cannot supply liquidity: Foucault, Kozhan, and Tham (2017), and Yang and Zhu (2017)
  - ▶ Non-HFTs cannot supply liquidity: Budish, Cramton, and Shin (2015) and Menkveld and Zoican (2017)
- Welfare implications often depend on exogenous roles

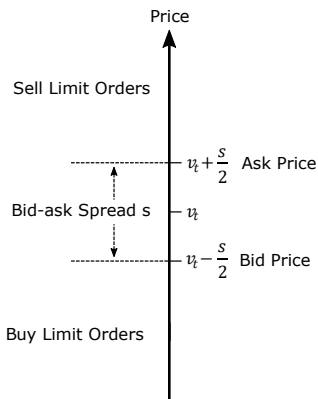
# Our Contributions

- Both HFTs and non-HFTs can demand and supply liquidity
- Discovers four types of equilibria
  - ▶ Who supplies liquidity depends on stock characteristics and market design
    - ★ Generates rich testable predictions
  - ▶ In one type, it is possible that everyone withdraws from supplying liquidity
    - ★ Leads to mini-flash crashes
- Challenges existing empirical proxies for HFTs' activity
  - ▶ Literature: higher cancellation-to-trade ratio implies more HFTs
  - ▶ Our paper: stocks with higher cancellation-to-trade ratio have less HFTs

# Roadmap

- Benchmark: [Budish, Cramton and Shim \(2015\)](#)
  - ▶ Two types of traders and continuous price
  - ▶ By assumption, HFTs supply liquidity
- Our contribution: who supplies liquidity depends on stock characteristics
  - ▶ Large tick size: queuing equilibrium
  - ▶ Small tick size
    - ★ Flash equilibrium
    - ★ Undercutting equilibrium
    - ★ Crash equilibrium
- Empirical predictions and policy implications

# Benchmark: Budish, Cramton and Shin (BCS, 2015)



**Bid-ask spread** is a measure of liquidity and is positive because of the sniping cost in [Budish, Cramton and Shim \(2015\)](#). We focus on sniping cost too.

# Model Setup

- Stock exchange operates as a continuous LOB with price-time priority rule
- One security,  $x$ , with fundamental value  $v_t$  following compound Poisson with  $\lambda_J$ ; common knowledge at  $t$
- $v_0 = 0$ ,  $\Delta v = \begin{cases} d & \frac{1}{2} \\ -d & \frac{1}{2} \end{cases}$
- Small latency to observe common value jump, can be reduced to 0 at cost  $c_{speed}$  per unit time
- Liquidity suppliers subject to being sniped when they fail to update stale quotes after jumps

# Model Setup, cont'd

- Agents

- ▶ HFT: no private value from trading; trade as long as expected profit  $> 0$
- ▶ Non-HFT: arrive with compound Poisson  $\lambda_i$ , need to buy/sell 1 unit of  $x$  with equal prob
  - ★  $\beta$  fraction are BATs - can use both limit and mkt orders
  - ★ remaining are non-algo traders - only mkt orders

- Pricing grid: large tick  $d$  vs small tick  $d/3$



## Model Setup, cont'd

- Markov perfect eq (actions at  $t$  depend only on state of LOB and events at  $t$ )
- Assume HFTs instantaneously build up the eq LOB after any event
- Events that trigger the transition of LOB across states:
  - ▶ BAT sells/buys (each with prob  $\frac{1}{2}\beta\lambda_I$ )
  - ▶ Non-algo sells/buys (each with prob  $\frac{1}{2}(1 - \beta)\lambda_I$ )
  - ▶ Price jumps up/down (each with  $\frac{1}{2}\lambda_J$ )

# Proposition 1 Queueing Equilibrium (Tick Size= $d$ )

- HFTs

- ▶ Quote a half bid-ask spread:  $\frac{d}{2}$
- ▶ Equilibrium queue length  $Q^*$  determined in the paper
- ▶ HFTs race to supply liquidity when queue length is small than  $Q^*$
- ▶ HFTs race to snipe stale quotes when value jumps

- BATs

- ▶ Demand liquidity

## Proposition 2: Flash Equilibrium

- BAT's strategy: supply liquidity to HFTs by crossing midpoint

- ▶ When  $\frac{1}{1-\beta} < \frac{\lambda_I}{\lambda_J} < \frac{1+2\beta+\sqrt{4\beta^2+9}}{2-\beta}$

- HFTs: three speed races

- ▶ Queue at half spread  $\frac{d}{2}$ 
  - ★ Supply liquidity to humans
- ▶ Demand liquidity
  - ★ Race to snipe other traders during value jump
  - ★ Race to take liquidity once BATs cross the midpoint

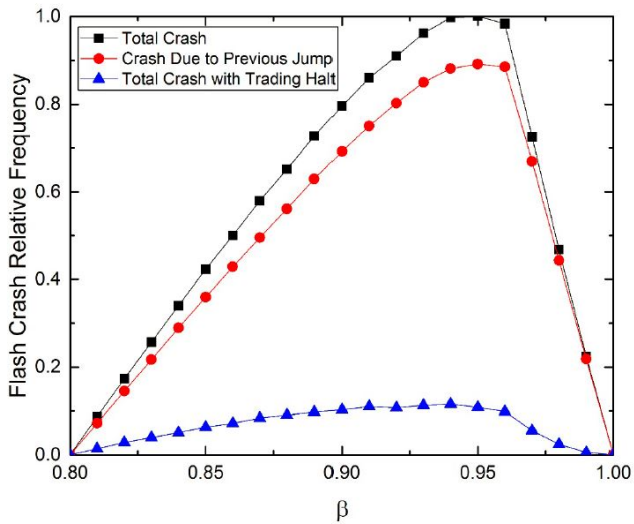
# Proposition 3: Undercutting Equilibrium

- BATs: undercut HFTs price and stay in the book
- HFTs:
  - ▶ Quote at  $\frac{d}{2}$  and add or cancel orders in response to BATs undercutting orders
  - ▶ Snipe during value jump

# Proposition 4: Crash Equilibrium

- HFTs quote a half-spread of  $\frac{7d}{6}$
- A BAT buyer (seller)
  - ▶ Quotes  $v_t - \frac{5d}{6}$  ( $v_t + \frac{5d}{6}$ ) if the price level has no limit orders
  - ▶ Otherwise, submits a flash limit order at price  $v_t + \frac{d}{6}$  ( $v_t - \frac{d}{6}$ )
- Mini-flash crashes occur when non-algos hit stub quotes
- The majority of mini-flash crashes occur after a value jump
  - ▶ Upward (downward) value jumps remove BATs limit orders from the ask (bid) side

# Flash Crash Intensity



# Predictions

- 1. (**Price Priority**): when tick size not binding, non-HFTs more likely to establish price priority in liquidity supply
- 2. (**Queuing**): HFTs crowd out liquidity supply when tick size binds, or when adverse selection is small.
- 3. (**Stub Quotes and Mini-flash crashes**): mini-flash crash more likely to occur when adverse selection risk is high or when tick size is small.
- 4. (**Speed competition of taking liquidity**): Non-HFTs more likely to supply liquidity at price levels crossing midpoint (flash limit orders); HFTs more likely to demand liquidity from flash limit orders, but do not adversely select these orders
- 5. (**Cancellation-to-trade ratio**): Stocks with a smaller tick size and higher adverse selection risk have a lower proportion of liquidity provided by HFTs, but a higher cancellation ratio.

# Conclusions

- Extend BCS
  - ▶ discrete tick size
  - ▶ Non-HFTs heterogeneity (BATs)
- Queuing channel of speed competition for liquidity supply (binding tick size constrain price competition, encourages HFTs speed competition)
- Speed competition in liquidity demand (HFTs race to demand liquidity from BATs flash limit orders)
- Mini-flash crashes occur when non-algos hit stub quotes
- Model yield predictions consistent with empirical evidence