High Frequency Trading and Welfare

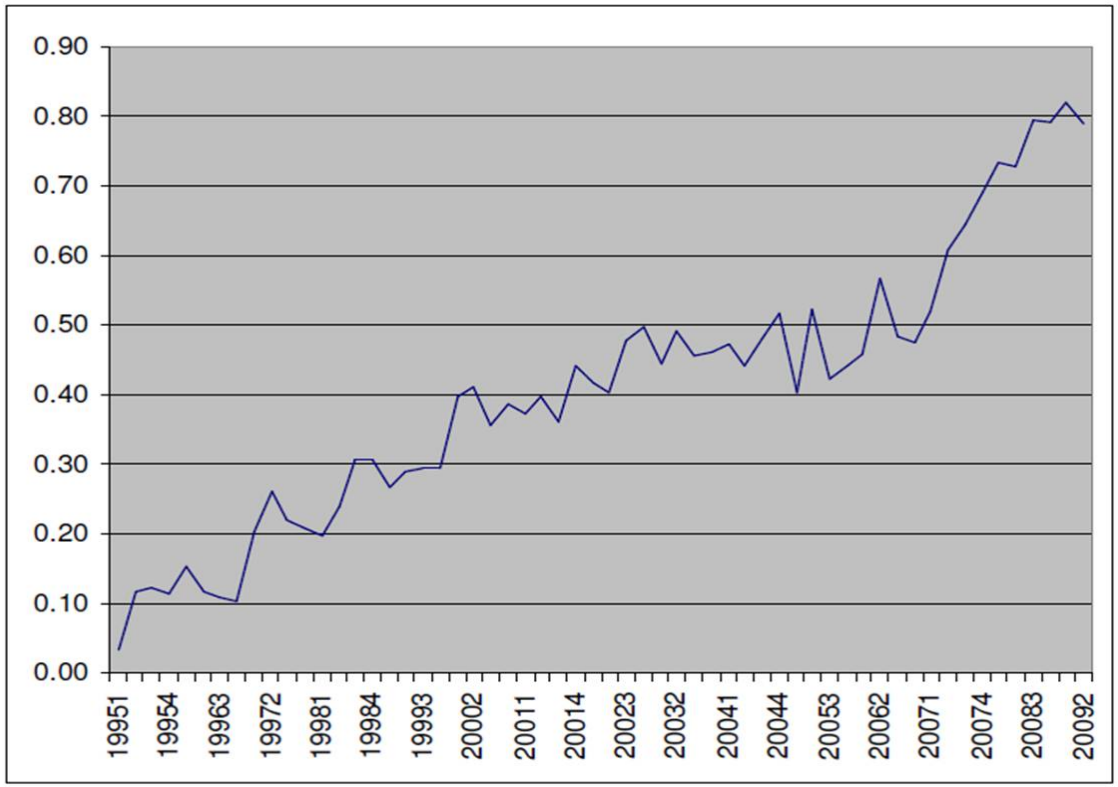
Paul Milgrom and Xiaowei Yu

Recent Development in the Securities Market

- 1996: Order Handling Rules are adopted. NASDAQ market makers had to include price quotes from electronic communication networks (ECNs) in their quotations.
- 2001: Decimalization.
- Late 1990s: advent of High Frequency Trading firms.
- 2005: Regulation National Market System (NMS-reg) is adopted. Trade (first unit) at best available price.
- Now: Many exchanges and ECNs have sub-millisecond latency.

The Dominance of HFT

- Brogaard (2010): 2009 data. 68% of total NASDAQ dollar-volume, 74 % of trade-volume
- Zhang (2010): 2009 data. 78% to total US equity dollar trading volume



HFTs have high trading speed

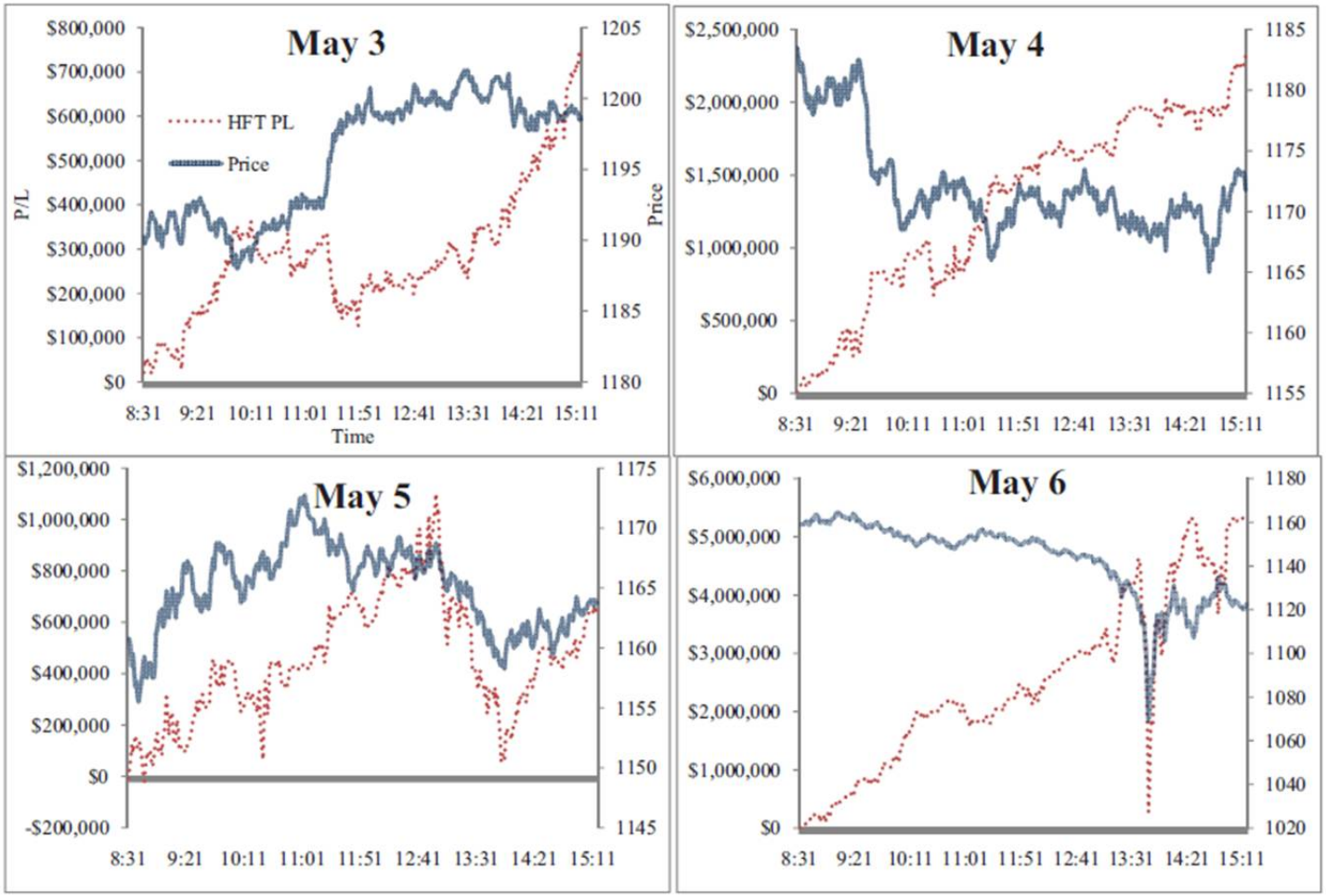
- Hasbrouck and Saar (2011): HFT's response time to market events is 2 - 3 milliseconds (Nasdaq, 2007 and 2008)
- Menkveld (2011): shortest time between cancel and resubmission is 1.67 millisecond. (A single HF trader, Chi-X market, Dutch index stocks, 2007 and 2008.)
- Gai, Yao and Ye (2012): shortest time between submission and cancelation < 1 microsecond (Nasdaq, 2010)

Investment on Speed

- Use Co-location services to save micro-seconds of latency
- Individual data feeds
- IEEE spectrum & Business week
  - In 2010, Spread Networks installed a fiber-optic communications cable between New York and Chicago which can reduce 1 millisecond
  - McKay Bothers and Tradeworks are developing microwave communication links between Chicago and New York which can be 30 percent faster than fiber-optic cables
  - $300 million transatlantic fiber-optic cable (open in 2013) is going to reduce the time it takes data to travel between New York and London by 5 milliseconds
- Laughlin, Aguirre and Grundfest (2012): 3 millisecond decrease in Chicago-NY latency from April 2010 to July 2012.
  - Fiber optic and wireless infrastructure cost $500 million.
  - Shorter than speed-of-light latencies imply predictions…

HFTs have consistent profit

Profits and Losses of HFT in the June 2010 E-Mini S & P 500 futures contract



"Flash crash" at 2:45PM.

Characteristics of HFT's Orders

- Establishing and liquidating positions within a short time. (Kirilenko et al 2010: HFT reduce half of their holdings in 137 seconds)
- High cancelation rate (Median across Nasdaq stocks: 96.5 %, Gai et al 2012)
- Short order duration (13% of orders are canceled within 50 millisecond, , Gai et al 2012)
- Similar amount of liquidity provision and liquidity demanding (Brogaard 2010: HFT demand liquidity: 43 % of Nasdaq market; HFT supply liquidity: 41 % of Nasdaq market)

Possible Strategies used by HFT

- Passive market making
- Arbitrage: cross assets; cross markets
- Directional trading: response to news faster; order anticipation.

Debate on High Frequency Trading

Proponents' arguments:

- HFT improves the price discovery process (Brogaard 2010, Broaard, Hendershott and Riordan 2012, Martinez and Rosu 2011)
- HFT reduces intraday volatility (Brogaard 2010, Hasbrouck and Saar 2011)
- HFT reduces spreads (Hasbrouck and Saar 2011)

Debate on High Frequency Trading

Opponents' arguments:

- HFT increases price volatility (Zhang 2010, Kirilenko, Kyle, Samadi, Tuzun 2011, Cartea and Penalva 2011, Jarrow and Protter 2011)
- HFT's arms race in speed has no social benefit (Gai, Yao and Ye 2012, Foucault and Moinas 2011, Laughlin, Aguirre and Grundfest 2012)
- HFT may complete for liquidity when rebalancing their positions (Kirilenko, Kyle, Samadi, Tuzun 2011)
- HFT increases liquidity traders' price impact (Cartea and Penalva 2011)

Is faster price discovery necessarily welfare improving?

Bresnahan, Milgrom and Paul (1992), "The Real Output of the Stock Exchange"

"…the information that is valuable for making a real decision – compensating managers or deciding on a new project – bears no relation to the information impounded in prices by the activities of traders…. Increased liquidity increases the resources devoted to informed traders' rent seeking, without improving any real investment decisions."

A simple model on order anticipation

An Example:

The limit order book: bid = $0.80, ask = $0.90

HFT knows the incoming slow trader is willing to buy at $1.00;

HFT quickly buys from the limit order book at $0.90 before the slow buyer, then quotes a new ask at $1.00 which will be taken by the slow buyer.

Spread: $0.10 without HFT; $0.15 with HFT.

Model Setup

- The fundamental value of the stock is common knowledge, normalized to be 0.
- Quantity of all orders is one. Limit orders last only one period.
- Four types of slow traders: buyers with private values Θ_L, Θ_H;

  sellers with private values $-\Theta_L$, $-\Theta_H$. $\Theta L < \Theta H$. High frequency traders have no private value of the stock.
- Slow traders only arrive at the market at t= 0, 1, 2, 3, … One slow trader arrives at each time. Trader type is iid, where probability of a low type buyer/sell is $p_L > 0$, and probability of a high type buyer/seller is $p_H > 0$. $p_L + p_H = 1/2$.
- Assume high frequency traders can trade any time at the market. They know the type of the incoming trader.
- Assume high frequency traders only trade when they can profit for sure. Thus they compete in speed to trade with the limit order book and do not compete in prices of limit orders.

Equilibrium without HFT

Assume $p_H < \frac{4\theta_L}{5\theta_L + 3\theta_H}$, both types of sellers choose the ask price to be the market buy threshold of the low type buyers (MB_L),

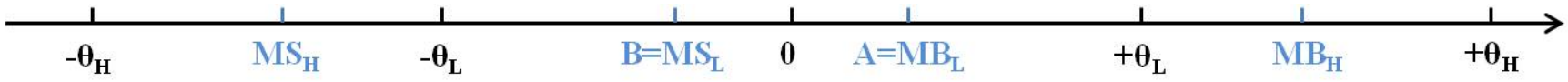
and both types of buyers choose the bid price to be the market sell threshold of the low type sellers (MS_L).

$$A = MB_L = \frac{\theta_L}{3}, \quad MB_H = \frac{\theta_H}{2} - \frac{\theta_L}{6}$$

$$B = MS_L = -\frac{\theta_L}{3}, \quad MS_L = \frac{\theta_L}{6} - \frac{\theta_H}{2}$$

$$Spread = A - B = \frac{2\theta_L}{3}$$

Equilibrium without HFT



In the steady state,

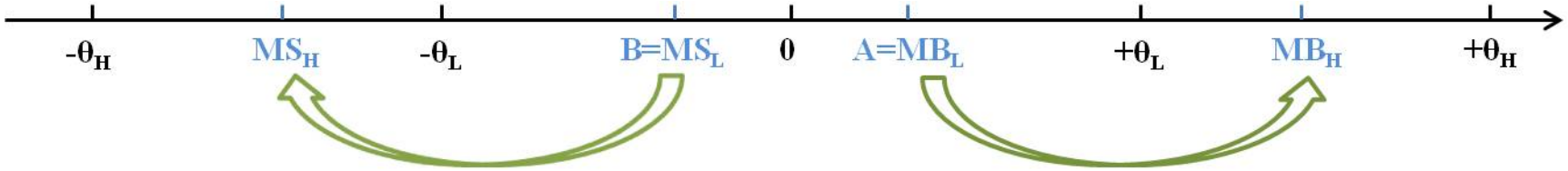
$$\pi_{LS} = \pi_{LB} = \frac{1}{3}$$

$$\pi_{MS_L} = \pi_{MB_L} = \frac{p_L}{3}$$

$$\pi_{MS_H} = \pi_{MB_H} = \frac{p_H}{3}$$

Equilibrium with HFT

Assume $p_H < \frac{4\theta_L}{5\theta_L + 3\theta_H}$, slow traders' strategies are the same as before. HF traders front run high type buyers/seller when there is a limit sell/buy order on the book.



High Frequency Trader:
First market sell order at $B = MS_L$;
Then limit buy order at MS_H.

High Frequency Trader:
First market buy order at $A = MB_L$;
Then limit sell order at MB_H.

What advantages over slow traders enable HFT to make profits?

- Compared to the early trader who posts the limit order, HFT knows the type of the incoming trader.
- Compared to the late trader who is going to trade with the existing limit order, HFT is faster in submitting the market order.

HFT's Welfare Impact

Consider the steady state.

Without HFT, low type's expected gain from trade: $\frac{2\theta_L}{3}$; high type's expected gain from trade: $\frac{2\theta_H}{3}$.

With HFT, low type's expected gain from trade: $\frac{2\theta_L}{3}$; high type's expected gain from trade: $\frac{\theta_H}{2} + \frac{\theta_L}{6} < \frac{2\theta_H}{3}$. HFT's expected profit per unit time: $\frac{p_H(\theta_H - \theta_L)}{3}$.

Thus, HFT makes profit in the expense of high type slow traders. The total welfare is lower in the equilibrium with HFT than without it if there is cost to become a HF trader.

HFT's Impact on Spreads

Consider the steady state.

Without HFT, $Spread = A - B = \frac{2\theta_L}{3}$

With HFT, $Spread = \bar{A} - \bar{B} = \frac{2\theta_L + p_H(3\theta_H - \theta_L)}{3(1+p_H)} > \frac{2\theta_L}{3}$

But data shows spreads have been decreasing in recent years. Why? Possible explanations:

- Information technology reduces the transaction cost.
- Limit order markets increase competition in liquidity provision.
- Some HFT strategies may reduce spreads.

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