High-Frequency Trading

David Sweet
April 17, 2014
What is HFT?
What is HFT?

- **Short-term Predictions**
- Equities, Futures, Options, Fixed Income
- Good Technology
- Automated
Short-Term Predictions

• Market Microstructure
• Index Arbitrage
• News Interpretation
• Market Center Rules/Design
• Counterparty Selection
Technology

- Software
- Hardware
- Network
- Telecommunications

FPGA, GPU, networking HW
Network Layout, packet loss, multicast, hops: distributed systems problem
CHI-NJ, NJ-NJ; Fiber, Spread, Microwave
Technology: Commoditized

- Data Hardware: NovaSparks, Celoxica, ActivFeed, xCelor
- Telecom: McKay Brothers, NASDAQ-CME MICROWAVE, NASDAQ OMX’s Metro Millimeter Wave
- Good Tech available via agency (ex., banks)
The “Value” of HFT
The “Value” of HFT

- People Trade to Make Money
- You Only Make Money If You’re Useful
What’s Useful To Markets & Investors?

- Increasing Price Efficiency
  - Lower Volatility
- Decreasing Executions Costs
  - Providing Liquidity, Decreasing Spreads

*one* driver of volatility is market efficiency
HFT Studies

- Increased Price Efficiency
- Lower Volatility
- Smaller Spreads
- More Liquidity

similar to trading on any other frequency
HFT Studies

Hendershott, Terrence, and Ryan Riordan. "High frequency trading and price discovery." Manuscript, University of California, Berkeley 3 (2011). "Overall HFT play a positive role in price efficiency by trading in the direction of permanent price changes and in the opposite direction of transitory pricing errors on average days and the highest volatility days."

Brogaard, Jonathan. "High frequency trading and its impact on market quality." Northwestern University Kellogg School of Management Working Paper (2010). "HFTs add substantially to the price discovery process, (7) HFTs provide the best bid and offer quotes for a significant portion of the trading day, but only around one-fourth of the book depth as do non-HFTs, and (8) HFTs do not seem to increase volatility and may in fact reduce it."


Riordan, Ryan, and Andreas Storkenmaier. "Latency, liquidity and price discovery." Journal of Financial Markets 15.4 (2012): 416-437. "system latency was reduced from 50 ms to 10 ms. Subsequently, both quoted and effective spreads decreased, "...indicating that prices are more efficient."
HFT Studies


• Jones, Charles. "What do we know about high-frequency trading." Research Paper 13-11 (2013). "Virtually every time a market structure change results in more HFT, liquidity and market quality have improved because liquidity suppliers are better able to adjust their quotes in response to new information."

<table>
<thead>
<tr>
<th>Company</th>
<th>Revenue ($B)</th>
<th>Revenue ($B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google</td>
<td>56.00</td>
<td>E*Trade</td>
</tr>
<tr>
<td>Coca Cola</td>
<td>47.00</td>
<td>ICE (owns NYSE)</td>
</tr>
<tr>
<td>Goldman Sachs</td>
<td>34.00</td>
<td>Fortress Invst. Group</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>32.00</td>
<td>KCG</td>
</tr>
<tr>
<td>Fidelity Investments</td>
<td>13.60</td>
<td>TD Ameritrade</td>
</tr>
<tr>
<td>Facebook</td>
<td>7.80</td>
<td>Virtu</td>
</tr>
<tr>
<td>Blackstone Group</td>
<td>6.60</td>
<td>HFT, US Equities/Firm</td>
</tr>
<tr>
<td>NASDAQ OMX</td>
<td>3.10</td>
<td></td>
</tr>
</tbody>
</table>

$1.3B 2013, Tabb Group estimate
*12 HFT’s in 2010 according to SEC/CFTA Flash Crash Report
maybe $/person would be a better metric
Crash!

Compare and Contrast Black Monday with the Flash Crash
Black Monday

October 19, 1987; DJIA
Black Monday

- DJIA Dropped 26% in One Day
- Largest One-Day Percent Decline in DJIA
Black Monday Cause

• Program Trading

• Or, Maybe Portfolio Insurance

• Or, Maybe Specialists, or Margin Rules, or Automated Quotes, or No Circuit Breakers, or …
Black Monday Cause

- "October's crash could be ascribed to the normal response of each country's stock market to a worldwide market movement."

- "Various institutional characteristics ... found to be insignificant"

Black Monday Events

- Crash Started in Hong Kong, Spread to Europe, then US, then Japan
- No “Rebound” in DJIA
- 1.5 Years Passed Before DJIA Drifted up to Pre-Crash Level
Black Monday Events

• ‘There was substantial selling pressure on the NYSE at the open on Monday with a large imbalance in the number of sell orders relative to buy orders. In this situation, many specialists did not open for trading during the first hour.’

• ‘The record trading volume on Oct. 19 overwhelmed many systems. On the NYSE, for example, trade executions were reported more than an hour late, which reportedly caused confusion among traders.’

• ‘Still, trading on Tuesday continued to be significantly impaired. Over the course of the day, about seven percent of stocks, including some of the most active, reportedly were closed for trading by the specialists as order imbalances made maintaining orderly markets difficult’

• A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response
Can you find it?
No, let’s zoom in...
Flash Crash

May 6, 2010
Flash Crash

- 1000 Point (9%) Swing in DJIA
- 2nd Largest Intraday Point Swing
Flash Crash Cause

- HFT

Obviously
Flash Crash Cause

• “…a large fundamental trader (a mutual fund complex) initiated a sell program to sell a total of 75,000 E-Mini contracts (valued at approximately $4.1 billion)”

• “Between 2:32 p.m. and 2:45 p.m., as prices of the E-Mini rapidly declined, the Sell Algorithm sold about 35,000 E-Mini contracts (valued at approximately $1.9 billion) of the 75,000 intended.”

• “This level of net selling by fundamental sellers is about 15 times larger compared to the same 13-minute interval during the previous three days”

• Findings Regarding the Market Events of May 6, 2010, Report of the Staffs of the CFTC and SEC to the Join Advisory Committee on Emerging Regulatory Issues
Flash Crash Cause

• "latency issues regarding a subset of pricing data on the consolidated market data feeds for NYSE-traded stocks triggered data-integrity checks in the systems of some firms."

• Price Integrity: Disagreement Among Exchanges, Large Price Changes

• Risk Limits: Positions Too Large

• Latency of Data

• Large Swings in PnL

• Internal Systems Unable to Handle Increased Messaging
Flash Crash Cause

• Integrity Checks ==> Trading Reduced

• On-Exchange Market Makers, Off-Exchange Market Makers, Equity HFT (Making/Taking)

• 6 of 12 HFTs Scaled Back Trading, 2 Stopped Trading

• HFT Volume from 53% (2:00-2:45) to 37% (2:46-3:00)

• Long-Term Avg.: 44% (May 3 - May 10)

Everyone reduced (for good reasons), not just HFT
HFT not that far off from long-term average; not a dramatic reduction
Compare

- Systems Overwhelmed by Messages, Information Delayed; Traders Confused
- Some Market Makers Couldn't Keep Up, Had to Pull Their Liquidity
- Causes Unclear During Crash
Contrast

- Black Monday: Didn't Rebound; DJIA Took 1.5 Years To Rise To Pre-Crash Level
- Flash Crash: Rebounded in 15 Minutes
- Black Monday: Inability of Markets to Handle World-Wide Correction Smoothly
- Flash Crash: Inability of Markets to Handle Sale of 15x Normal Volume Smoothly
- Black Money: Markets Equilibrated in ~2 Days
- Flash Crash: Markets Equilibrated in ~15 Minutes

Congrats, Equities Markets!
Reg NMS
Reg NMS

- SEC Regulation NMS
- National Market System
- Foster Competition Between Exchanges While Protecting Investors
Reg NMS

- **Order Protection Rule**: Trade at Best Price on Any Market, NBBO

- **Access Rule**: Same Price for Anyone to Access Market, No Locked or Crossed Markets

- **Sub-Penny Rule**: $.01 Tick Size for All Stocks Priced Over $1

- **Market Data Rules**: SIP, Aggregate and Publish NBBO

**NBBO - National Best Bid and Offer**

**SIP - Securities Information Processor**
Reg NMS: Impact

• Competition/Fragmentation: >12 exchanges, >60 other market centers (*Testimony of Erik R. Sirri*)

• Many Nuanced Order Types Designed to Cope With Reg NMS Rules

• Multiple Market Centers Creates High Message Rates; Need to Process, Store, and Analyze These Messages
Reg NMS: Impact

- Complexity? Technology? Distributed Systems?
- HFT!
Reg NMS: Impact

• "more fragmented stocks have lower transactions costs and faster execution speeds; and fragmentation is associated with higher short-term volatility but greater market efficiency, in that prices are closer to being a random walk. Our results that fragmentation does not appear to harm market quality are consistent with US markets being a single virtual market with multiple points of entry."

Reg NMS: Impact

- Thu Aug 22, 2013: NASDAQ Couldn't Connect to an Overloaded SIP to Publish Tape C NBBO
- Reg NMS Order Protection Rule Requires Publication of NBBO for **Any** Participant to Trade
- **Single Point of Failure**
- All of Tape C Was Halted for 3 Hours
Reg NMS: Impact

• "Our review indicates that high frequency trading played no role in the technology events of August 22."


ARCA Overloaded the SIP
Reg NMS being reviewed by SEC now
Internalization
Internalization

Market Makers Execute Retail Orders
Internalization

• **Market Maker Pays Discount Broker** for Retail Orders

• Market Maker Obligated to Execute Orders

• Market Maker Obligated to Stay Within NBBO

• Market Makers: KCG, Citadel, Goldman Sachs, Others

• Discount Brokers: E*Trade, TD Ameritrade, ScottTrade, Others

Trivia: Invented by Bernie Madoff
Internalization

- Retail Trader Pays Discount Broker Commission
- Retail Order Executes Off Market
- Order Doesn't Interact With Orders In Market

Notice Discount Broker gets paid twice
Internalization

- "more than 200 broker/dealers" internalize
- "almost 100% of all retail" orders are internalized
- *Dark Pools, Internalization, and Equity Market Quality, CFA Institute (2012).*
Internalization

- Weaver, Daniel. "Internalization and market quality in a fragmented market structure." Available at SSRN 1846470 (2011). "...that internalization is directly related to spread width (quoted, effective, and realized). I also find that the percentage of volume internalized is directly associated with price impact per trade and volatility."


- Grammig, Joachim and Theissen, Erik, Is Best Really Better? Internalization in Xetra BEST (March 2005). "suggesting that internalization can be profitable for both customer and internalizer."