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."

Hasbrouck, Joel, and Gideon Saar. "Low-latency trading." Journal of Financial Markets 16.4 (2013): 646-679. "Our analysis suggests that increased low-latency activity improves traditional market quality measures—decreasing spreads, increasing displayed depth in the limit order book, and lowering short-term volatility."

Hagströmer, Björn, and Lars Nordén. "The diversity of high-frequency traders."Journal of Financial Markets 16.4 (2013): 741-770. "we find that the activity of market-making HFTs mitigates intraday price volatility."

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

- *Brogaard, Jonathan, et. al. "High-Frequency Trading and the Execution Costs of Institutional Investors", FSA Occasional Paper Series 43 (2013).* "we find no evidence that these increases in HFT activity impacted institutional execution costs."
- *Angel, James J., Lawrence E. Harris, and Chester S. Spatt. "Equity trading in the 21st century." The Quarterly Journal of Finance 1.01 (2011): 1-53.* "Virtually every measurable dimension of US equity market quality has improved."
- *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."
- *Chaboud, Alain, et al. "Rise of the machines: Algorithmic trading in the foreign exchange market." Journal of Finance, Forthcoming (2013).* "...we find clear evidence that algorithmic trading causes an improvement in two measures of price efficiency in this market: the frequency of triangular arbitrage opportunities and the autocorrelation of high-frequency returns."

Revenue, 2013

	Revenue ($B)		Revenue ($B)
Google	56.00	E*Trade	1.70
Coca Cola	47.00	ICE (owns NYSE)	1.70
Goldman Sachs	34.00	Fortress Invst. Group	1.30
Morgan Stanley	32.00	KCG	1.00
Fidelity Investments	13.60	TD Ameritrade	0.73
Facebook	7.80	Virtu	0.66
Blackstone Group	6.60	**HFT, US Equities/ Firm**	**0.11**
NASDAQ OMX	3.10		

$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"
- *Roll, Richard. "The international crash of October 1987." Financial analysts journal (1988): 19-35.*

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*

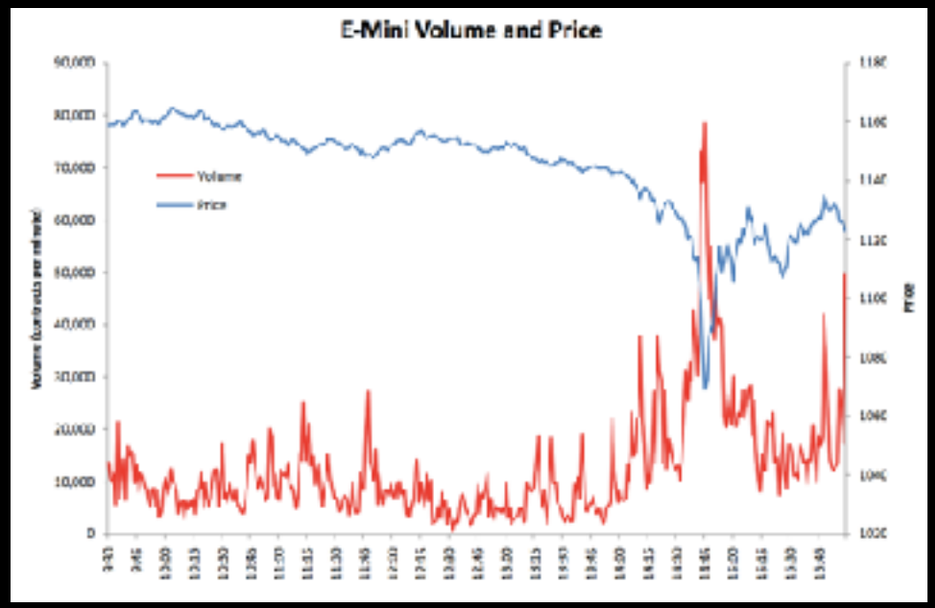
Flash Crash

May 6, 2010; DJIA

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
- *https://www.sec.gov/rules/final/34-51808.pdf*

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."

- *O'Hara, Maureen, and Mao Ye. "Is market fragmentation harming market quality?." Journal of Financial Economics 100.3 (2011): 459-474.*

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

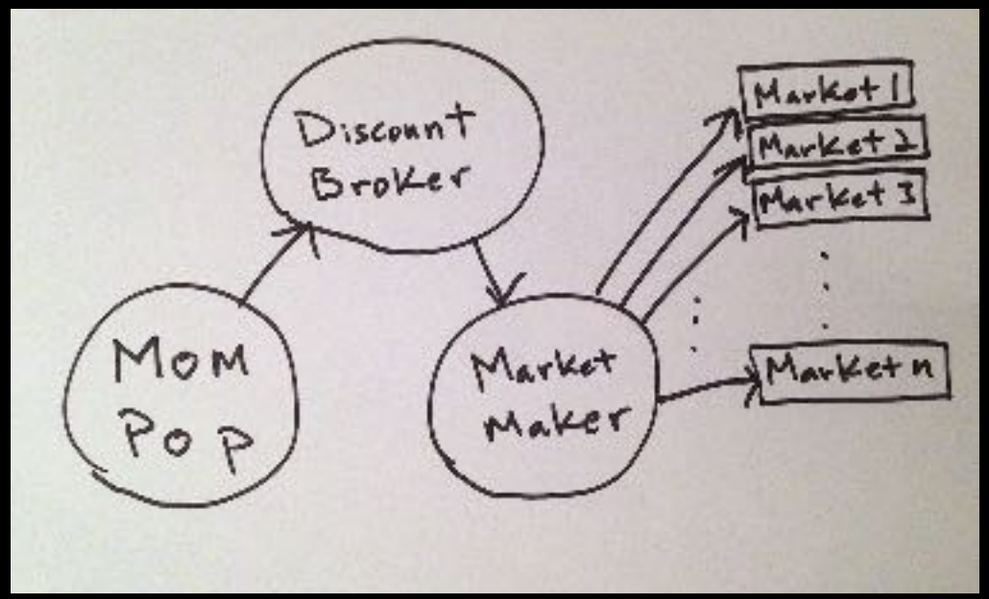
- "Our review indicates that high frequency trading played no role in the technology events of August 22. "
- *http://ir.nasdaqomx.com/releasedetail.cfm?ReleaseID=787888, Press Release for Details on Preliminary Findings of Internal Review*

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."

- *Larrymore, Norris L., and Albert J. Murphy. "Internalization and market quality: An empirical investigation." Journal of Financial Research 32.3 (2009): 337-363.* "We find that the rule revision is accompanied **by falls in the bid–ask spread and the variance of the pricing error** and by **rising internalization rates**."

- *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**."

Mixed Reviews