

Precision Timing and High-Speed Trading in Financial Markets

Austin Gerig

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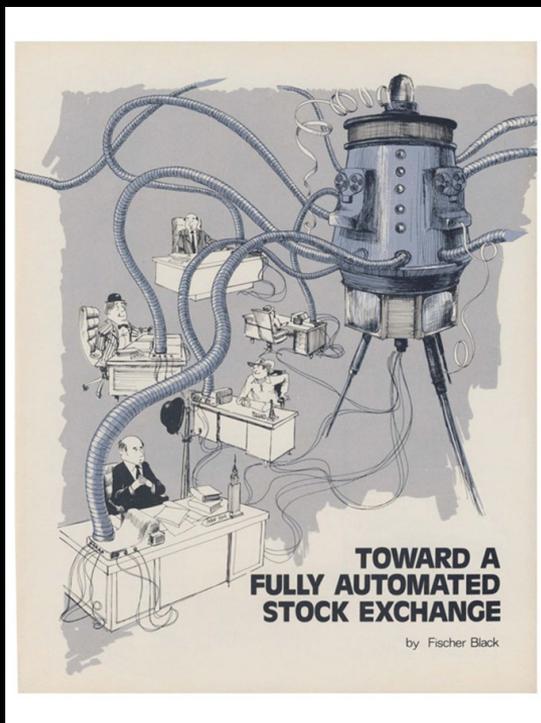
Outline

- High-Speed Trading
 - History of automation
 - Speed in markets
- Use of precision timing
 - Patterns in transaction timestamps
 - Transaction timestamps can reveal information about:
 - Trading strategies
 - Geographic location
 - Technological sophistication

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The automation of financial markets



In 1971, Fischer Black predicted that most activity on financial exchanges could (and would) be automated.

Also: Demsetz (1968), Black (1971), Fama (1970 pg. 399), Garbade and Silber (1978), Hakansson, Beja, and Kale (1985), Amihud and Mendelson (1988)

Complete mechanization



“Originally, the universal assumption had been that automated trading would involve a human being inputting orders into a computer terminal.”

“... perhaps human beings, with their inevitably slow reaction times, could then be removed altogether from electronic trading and replaced by entirely automatic systems?”

-Mackenzie (2013)

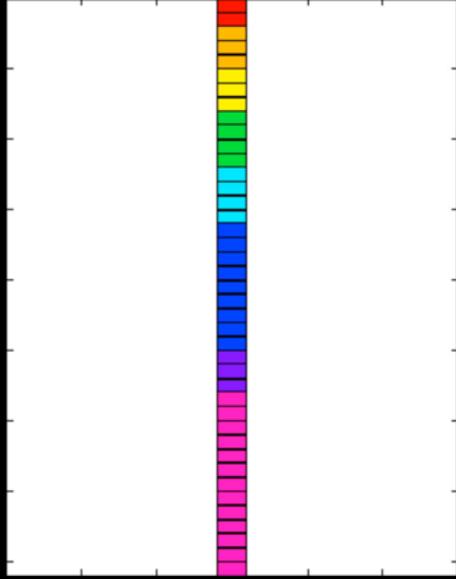


Questions

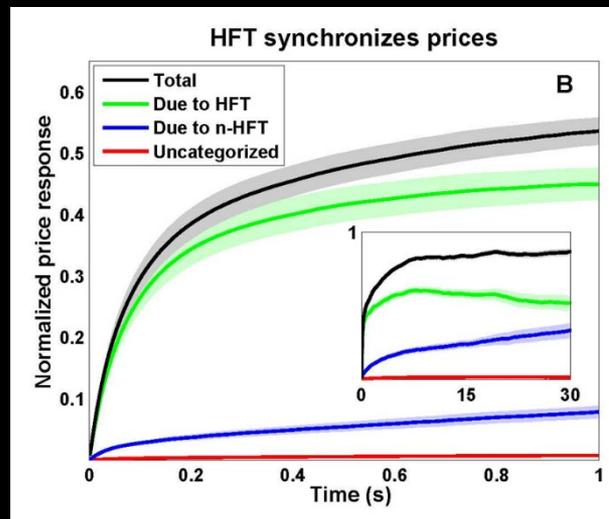
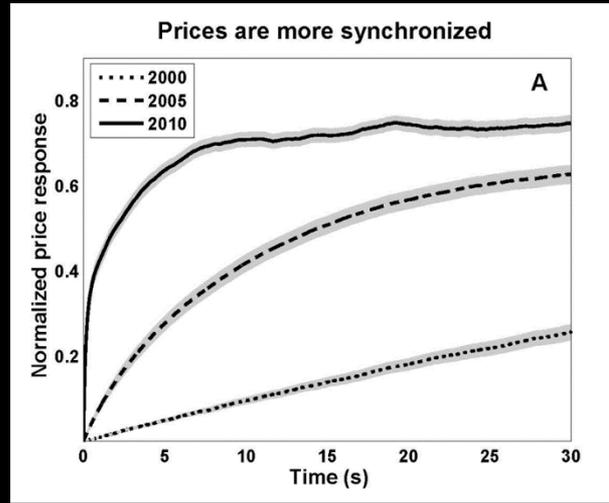
- Why are markets now automated ... what's the advantage?
- Are markets too fast or too slow?

Collective motion in nature





Price movements of 40 large-cap US stocks in one minute intervals on Feb. 24, 2010. Colors correspond to market sector. (Gerig 2015)





PHOTOGRAPHER: JUNKO KIMURA/GETTY IMAGES

WALL STREET

How High-Speed Traders Are Like Fish

By Mark Buchanan

At precisely 4:00:00 p.m. on Dec. 5, closing time for the Nasdaq stock exchange, a company called Ulta Salon Cosmetics & Fragrance announced worse-than-expected earnings. By 4:00:01 p.m., in the one second Nasdaq required to calculate the final stock price, high-speed traders with access to direct news feeds had already knocked it down by about 3 percent.

Mark Buchanan, a physicist and Bloomberg View columnist, is the author of the book "Forecast: What Physics, Meteorology and the Natural Sciences Can Teach Us About Economics." Read more.

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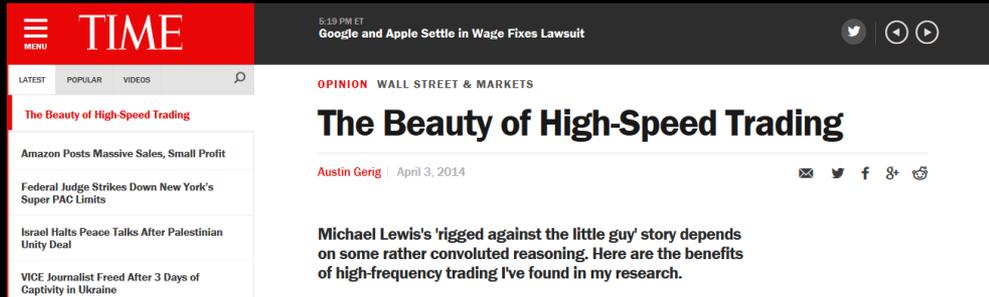
WE ASK
Barry Ritholz
How Rich Are the Rich?

WALL STREET

High-Frequency Trading May Be Too Efficient

By Matt Levine

If by some ghastly mistake I were put in charge of regulating the world's financial markets, my first order of business would be to find an organizing principle or slogan or whatever to direct my regulating. "Fairness" and "transparency" and "looking out for the little guy" seem to be popular slogans for the world's actually existing market regulators, but I think my slogan might be "the Grossman-Stiglitz paradox." This is the idea that if markets are efficient -- if market prices accurately reflect all the information in the world -- then



MENU TIME

5:19 PM ET
Google and Apple Settle in Wage Fixes Lawsuit

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OPINION WALL STREET & MARKETS

The Beauty of High-Speed Trading

Austin Gerig | April 3, 2014

Michael Lewis's 'rigged against the little guy' story depends on some rather convoluted reasoning. Here are the benefits of high-frequency trading I've found in my research.

“Put simply, (the beauty of high-frequency trading) is the following: High-frequency trading synchronizes prices across global financial markets. It knits exchanges together into one gigantic marketplace where the prices of financial securities move in unison, much like a school of fish.” (Gerig, 2014)

Speed in markets

- Modern financial markets are *really fast*
- Current latency:
 - intramarket: 1-100 microseconds
 - intermarket: 0.1 – 100 milliseconds
- Are these speeds really necessary?

... probably not necessary for price discovery

- “... price discovery at the nano-second interval cannot possibly give a significant allocative efficiency benefit over price discovery on a second-by-second basis.”

– Adair Turner,
FSA Chairman (at the time)



What about liquidity/transaction costs?

- There is no need for markets to clear faster than the rate of order arrival
- ... but, the current rate of order arrival is very high
 - on average, there is more than one U.S. equity trade *per millisecond* during the trading day (see www.utpplan.com)
 - milliseconds might be important!!!

Fricke and Gerig (2015)

- We model/simulate the arrival and mixing of orders over different time intervals
- **Main result: liquidity is maximized at intermediate speeds**
 - if too slow, orders “sit” too long before transacting
 - if too fast, not enough orders are “mixed”
- We estimate the optimal clearing speed for a typical U.S. stock:
 - **0.2 to 0.9 seconds**
- For many securities, markets are perhaps unnecessarily fast

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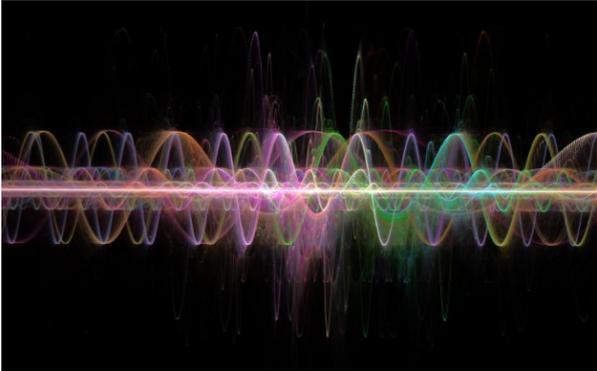
ASSET MANAGEMENT

Modal patterns in market data stump Morgan Stanley quants

New research suggests algo traders are changing the market microstructure


Faye Kilburn
@Fayekilburn
15 May 2017





Quants have discovered a distinctive modal pattern in market data

Data scientists at Morgan Stanley are scratching their heads after observing a mysterious modal pattern in market data, which they attribute to systematic trading activity.

- Also see Hasbrouck and Saar (2013)

Motivation

- Why would firms or trading venues have different timing patterns?
 - Differences in trading system architecture and sophistication
 - Differences in trading system locations
 - Differences in strategies
- Purpose of categorizing patterns:
 - Transaction timestamps can reveal a firm or trading venue's technological sophistication, location, and/or trading strategy

Questions

- Do patterns exist in timestamps and time lags of US equity transactions?
- What can explain the patterns?

Data

- TAQ data (trade and quote data)
 - Publicly available data containing SIP messages: equity trades and quotes
 - We use the “participant timestamp” field, which is the timestamp applied by the trading venue
 - Dropped duplicates of: {symbol, exchange, date, time}

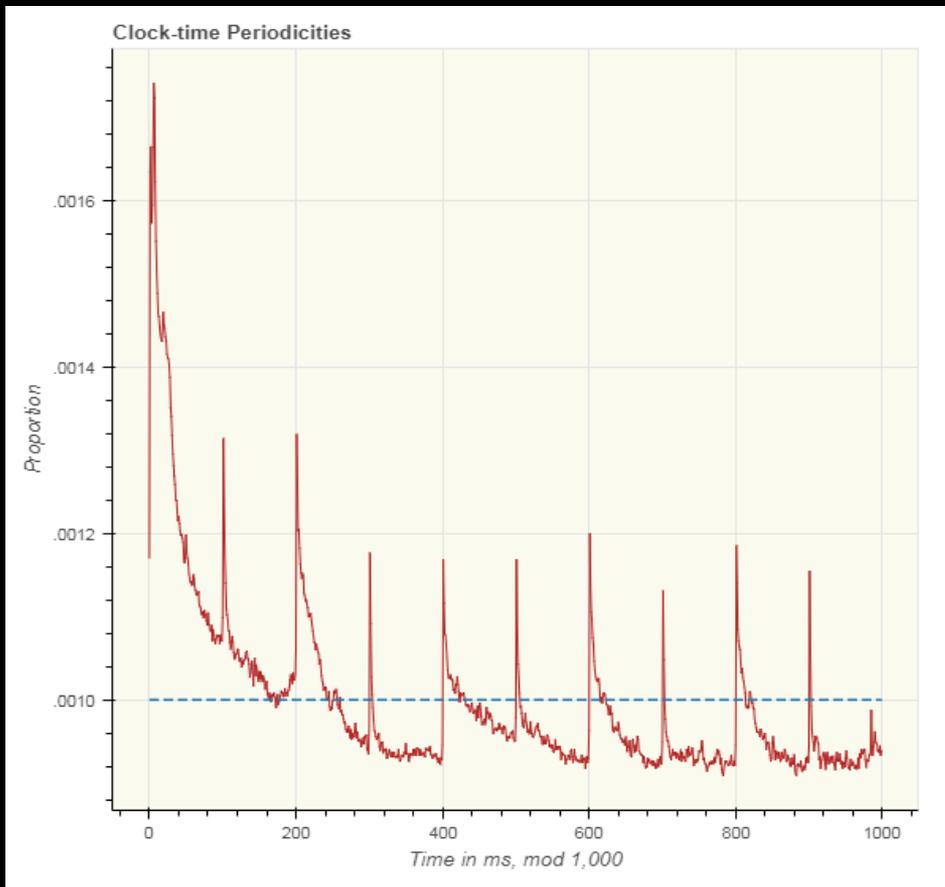
Two Measurements

- Transaction timestamps
 - Timestamp of the transaction
- Time between transactions
 - Time between two consecutive transactions

Transaction Timestamps

- Null hypothesis
 - Uniform distribution of digits

Transaction Timestamps



Timestamps are much more likely to be at or near whole seconds than fractional seconds. Spikes also occur for tenths of seconds.

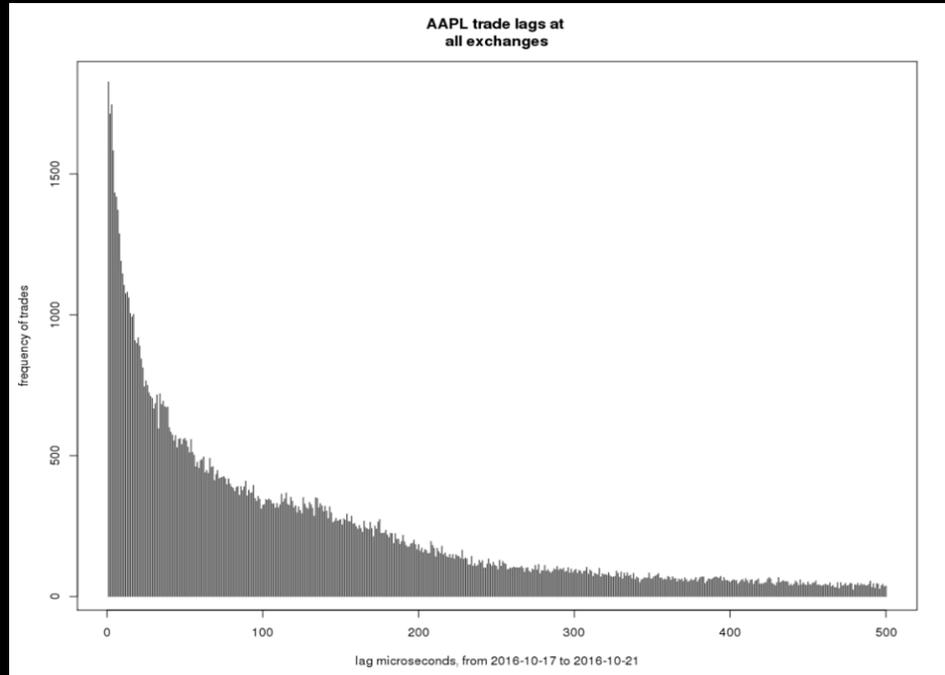
Possible explanation: many algorithms are programmed to “fire off” orders at whole seconds instead of randomizing time.

Data: TAQ January – June 2017 top 500 stocks by market cap.

Time Between Transactions

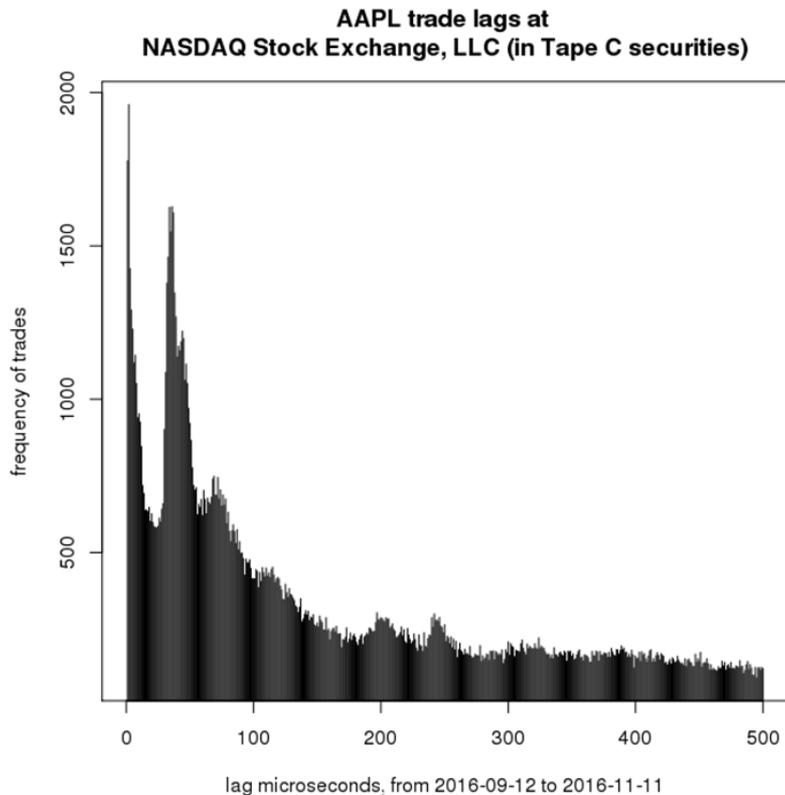
- Null hypothesis
 - Exponential (Poisson process, i.e., independent events)

Time Between Transactions



When aggregating across all exchanges, there's a structure break in the decay of the distribution at about 200 microseconds, which is suggestive that two different processes with different inherent timescales are at play.

Time Between Transactions

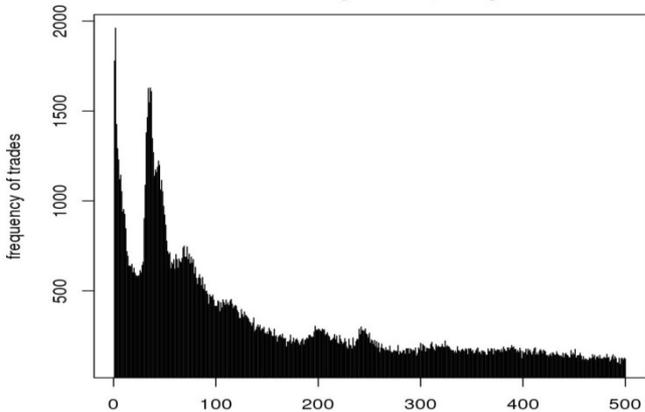


There's 'echo' transactions on individual exchanges which can be seen as humps in the distribution. (For Nasdaq, these echos occur at about 40 microseconds, 75 microseconds, 200 microseconds, and 240 microseconds.)

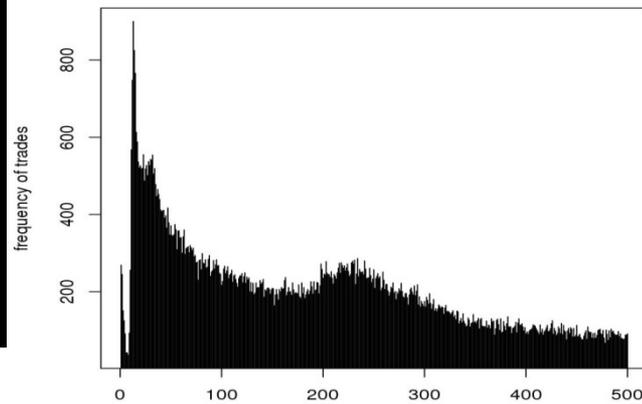
Possible explanation: Algorithms react immediately to transactions, but are located at different geographic locations and therefore take different characteristic times to cause reactionary transactions.

Patterns at Different Exchanges

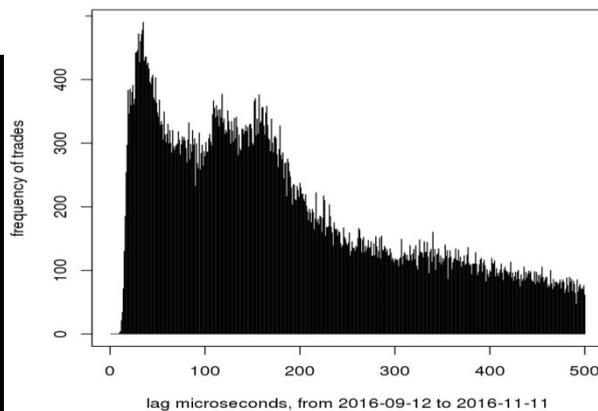
**AAPL trade lags at
NASDAQ Stock Exchange, LLC (in Tape C securities)**



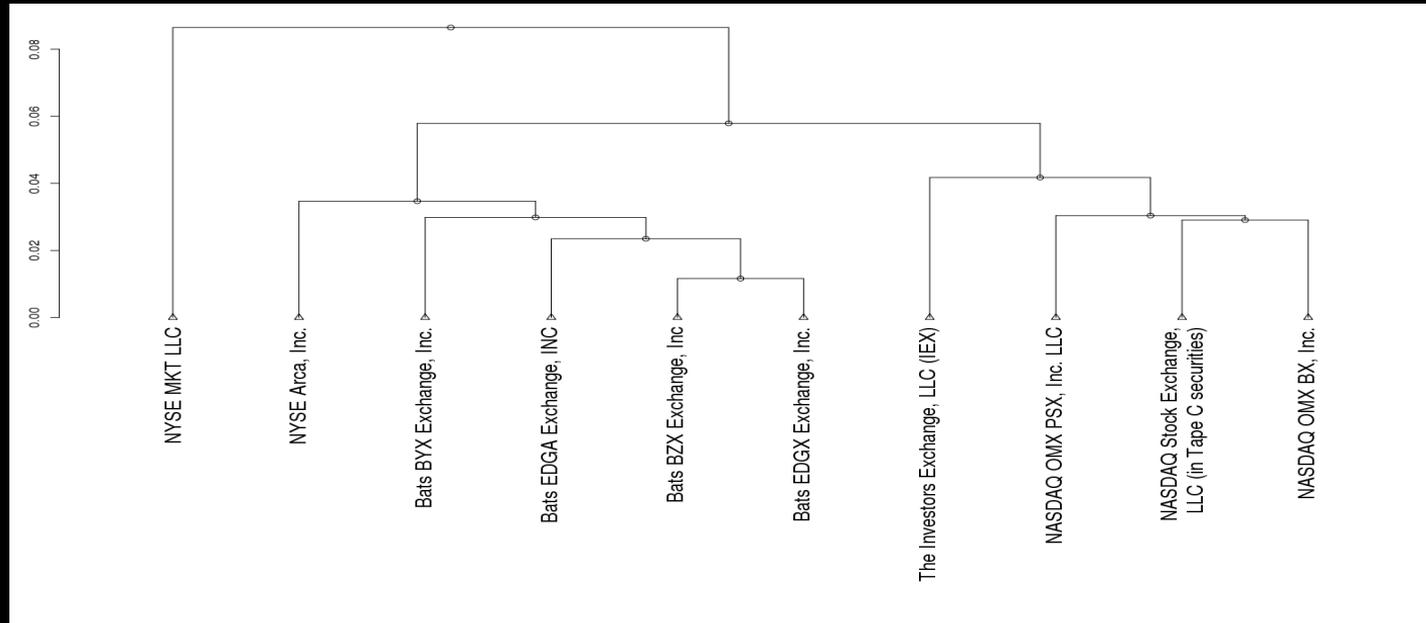
**AAPL trade lags at
NYSE Arca, Inc.**



**AAPL trade lags at
Bats EDGX Exchange, Inc.**



Cluster Analysis



When clustering timing patterns by exchange, we find clusters based on geographic location

Conclusions

- Transaction timestamps can reveal information about:
 - Trading strategies
 - Geographic location
 - Technological sophistication
- Preliminary analysis suggests:
 - many trading firms do not randomize the timing of their algorithms
 - implication: the trades of many firms might be more predictable than they realize
 - geographic location plays an important role in determining time lag patterns
 - implication: time lag patterns might be used to reveal a firm or venue's location