

*MODERN HIGH-FREQUENCY TRADING WOULD  
BE IMPOSSIBLE WITHOUT SUPER  
SOPHISTICATED SOFTWARE*

# [SOCIAL] THREATS OF AI

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# GOALS

- Understand how AI is used in finance
- Understand the risks of using AI in finance
  - High frequency trading
  - Robot advisors
- End with - should technology be neutral

FINANCE STARTS WITH TIME  
VS MONEY



# WHAT IS FINANCE?

- Two related activities
  - The story of how money is managed.
  - Actual process of acquiring needed funds.
- Usually separated into three sub-categories:
  - Personal finance
  - Corporate finance
  - Public finance



# AI IN FINANCE

- Early stage of disrupting the finance sector.
- Computers can easily beat analysts and associates who crunch numbers on an excel sheet.
- Trend of open source platforms

# Artificial intelligence quantitative funds and DIY funds landscape

## Advanced knowledge in algorithmic trading required

Institutional hedge funds using AI quant strategy\* and also source talents via challenges, academics and partnerships



Crowdsourced quant hedge funds

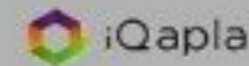


Online community for quant traders



## Limited knowledge in algorithmic trading required

Algorithmic marketplace



Pure AI quant hedge fund, open to public investors



Tools to design executable quant strategies without coding skills needed



Institutional hedge funds using AI quant strategy\*



Pure AI quant hedge funds



Tool to optimize trading algorithm



Social trading platforms



\* Among other strategies

Note: AI refers to Artificial Intelligence; Quant refers to quantitative



# SOME TERMS

Stock

Supply - the volume or abundance of a particular item in the marketplace.

Demand refers to an individual's willingness to pay a price for an item or stock.

Bid, ask, spread:

- Company A wants to purchase 1,000 shares of X stock at \$10
- Company B wants to sell 1,500 shares at \$10.25.
- The spread is the difference between the asking price and the bid price (25 cents).
- An individual investor wanting to sell 1,000 shares, knows he could do so at \$10 by selling to Company A.
- Conversely, the same investor would know that he could purchase 1,500 shares from Company B at \$10.25.



# SOME TERMS

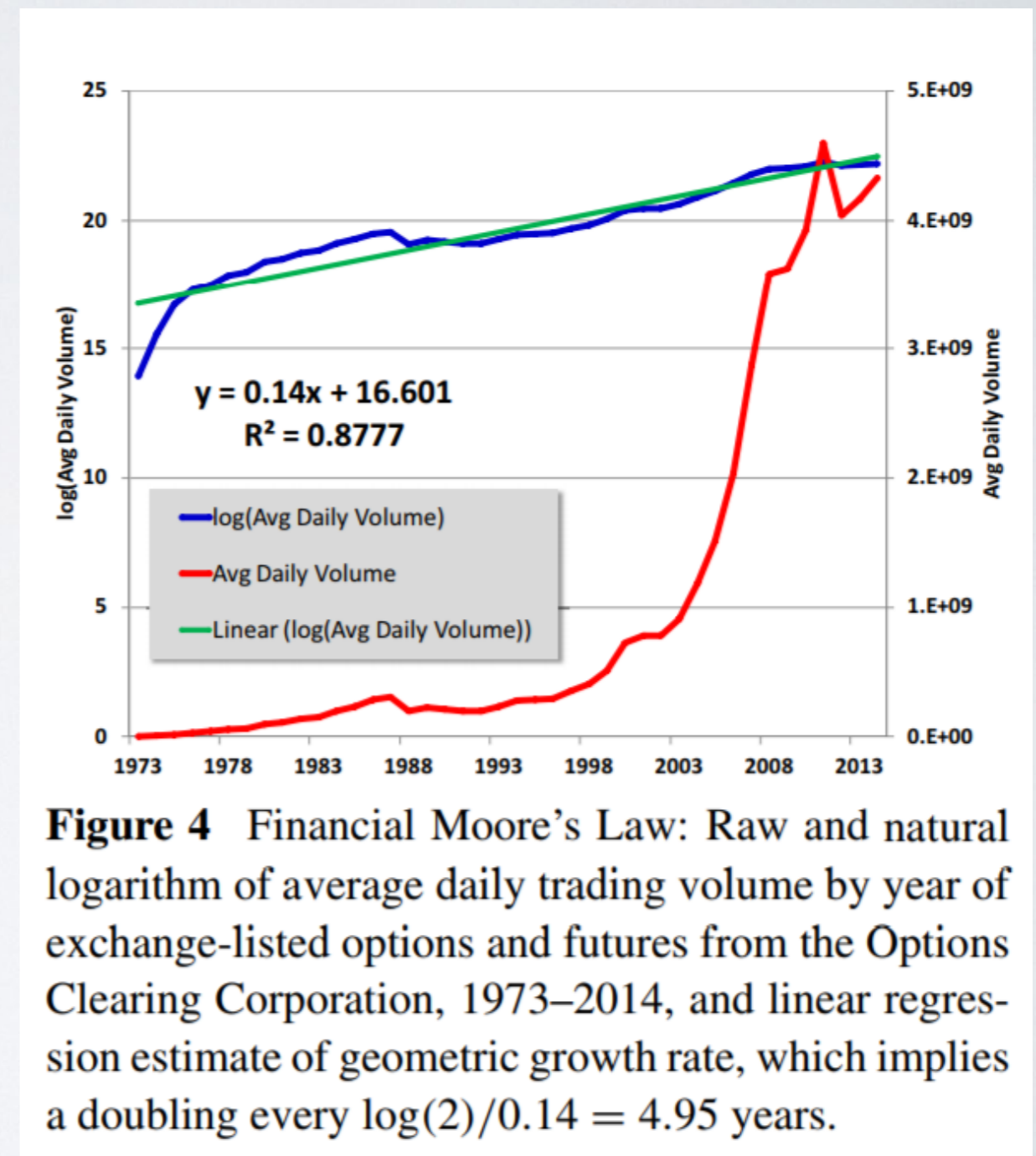
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# WHY NOW- MOORE'S LAW

Because of Moore's Law:

- Automated algorithmic trading
- Online trading
- Mobile banking
- Crypto-currencies like Bitcoin
- Crowdfunding
- Robo-advisors





# WHY NOW?

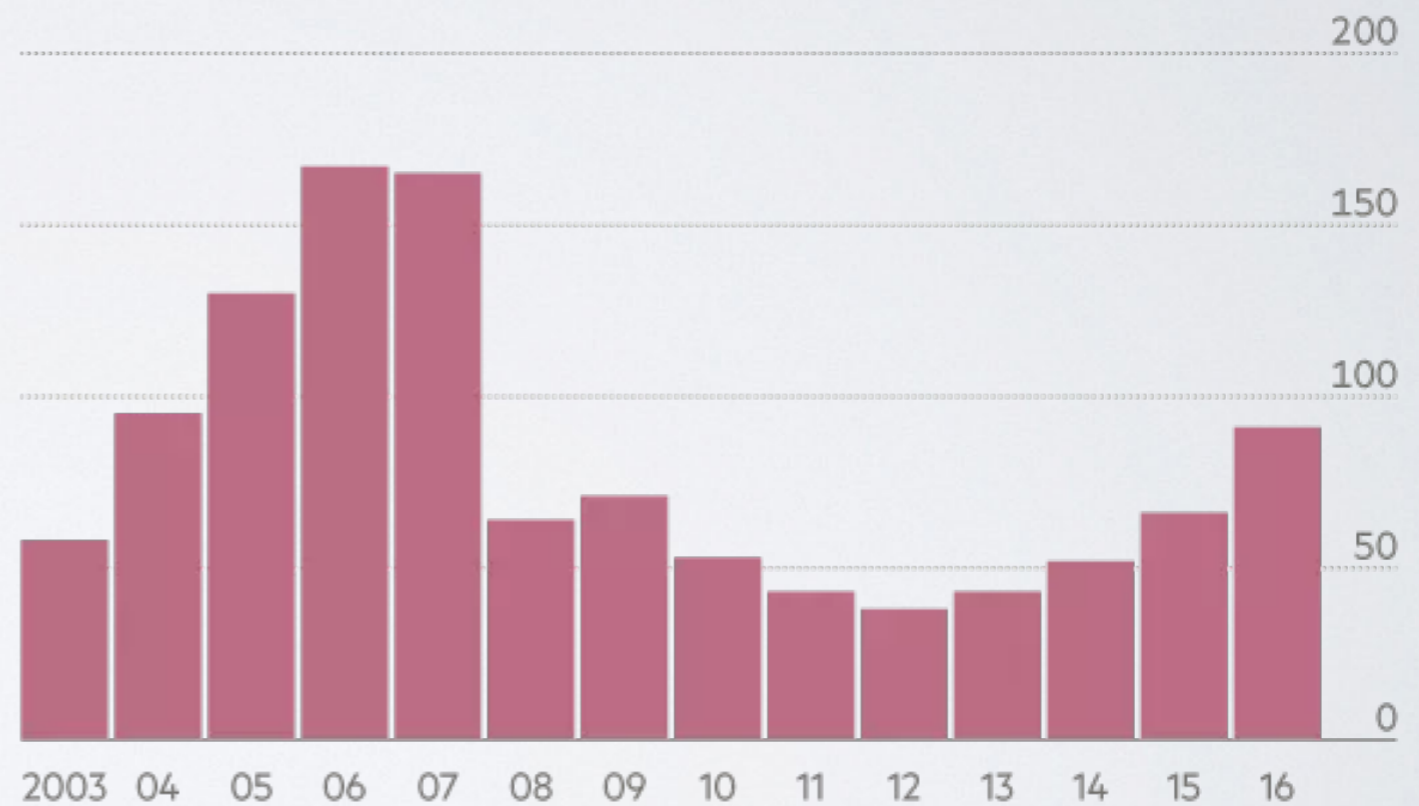
- The collective intelligence of the market is dependent on:
  - rapid collection of accurate information
  - has been greatly magnified by the advances in telecommunications, processing power, and data storage that **Moore's Law has made possible.**
- As a result, the financial industry must weigh Moore's Law against Murphy's Law, as well as Kirilenko and Lo's (2013) technology-specific corollary: "Whatever can go wrong, will go wrong faster and bigger when computers are involved."



# GOLDMAN SACHS

- In 2000 there were 600 equity traders in NY
- 2017 there were 2 equity traders in NY and 200 engineers
- They have found that one computer engineer can replace four traders.

The unlikely renaissance of Goldman Sachs' quants  
QIS unit's assets under supervision (\$bn)



Source: Goldman Sachs

# GOLDMAN SACHS TRENDS

- Natural language processing to look for verbal cues from analysts on a call.
- “There’s a tendency towards praise to keep in management’s good books, but only marginally. If 20 out of 30 analysts say ‘great quarter’ then it probably was,” Mr Walsh says.

# ATTEMPTED THEFT

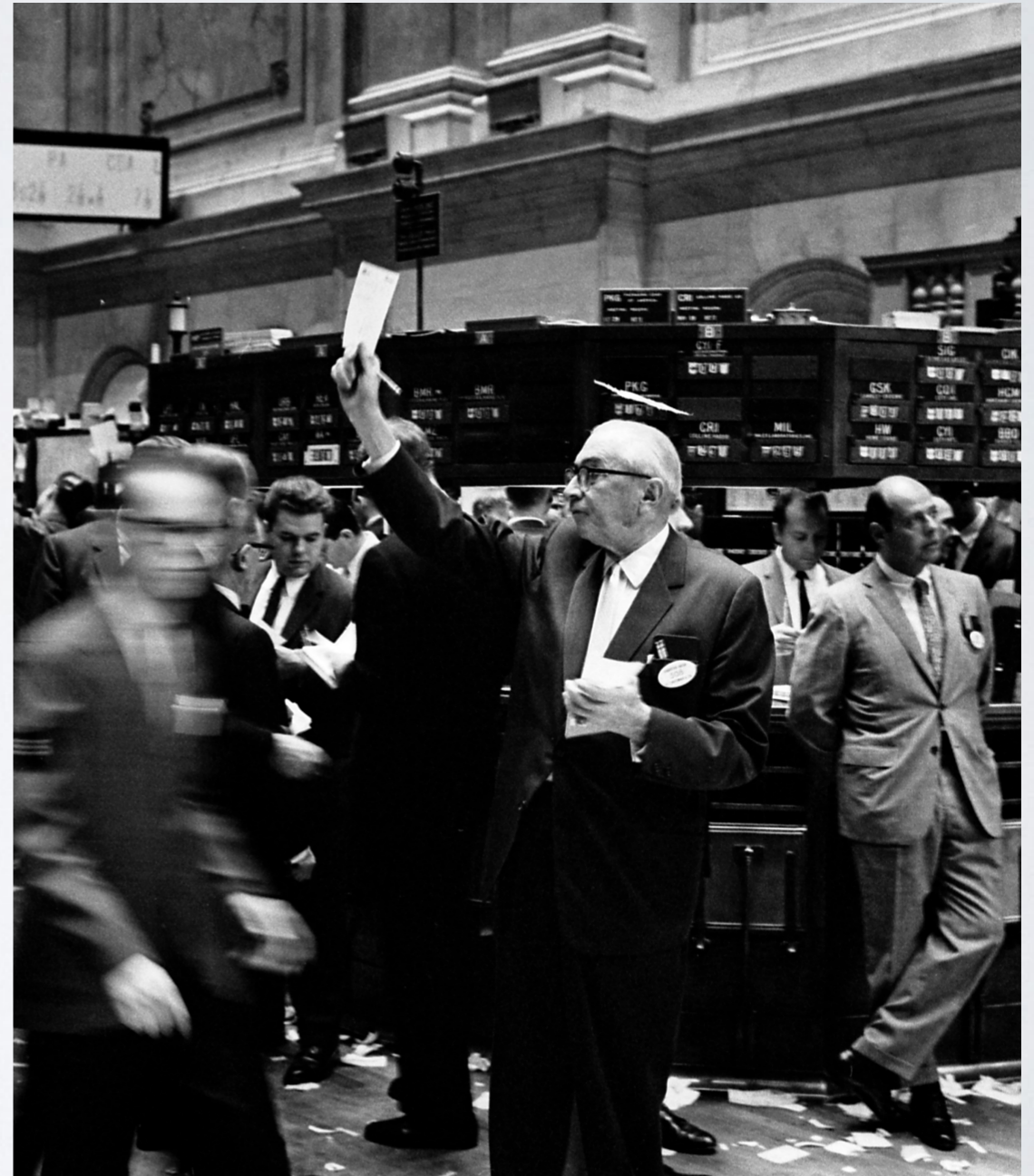
- In July 2009, Goldman Sach's proprietary algorithmic trading code was allegedly stolen by Sergey Aleynikov.
- The platform trading of stocks and commodities, a high-frequency trading platform that Aleynikov himself supposedly helped create.
- Federal authorities claimed the platform contained Goldman's top secret mathematical formulas and algorithms.



# HIGH-FREQUENCY TRADING

# WHAT IS HFT?

- Used to be human traders, now computers.
- Traders monitoring computers
  - Computers are faster
  - Computers don't go on vacation.
  - Little human supervision.





# BIG IDEA

- There is no interest in actually owning a company's stock.
- The game is to sell it on at a fraction of a penny's profit very, very quickly.
- The tiniest delay is the difference between profit and loss.



# AI HAS TIME/ENERGY ON ITS SIDE

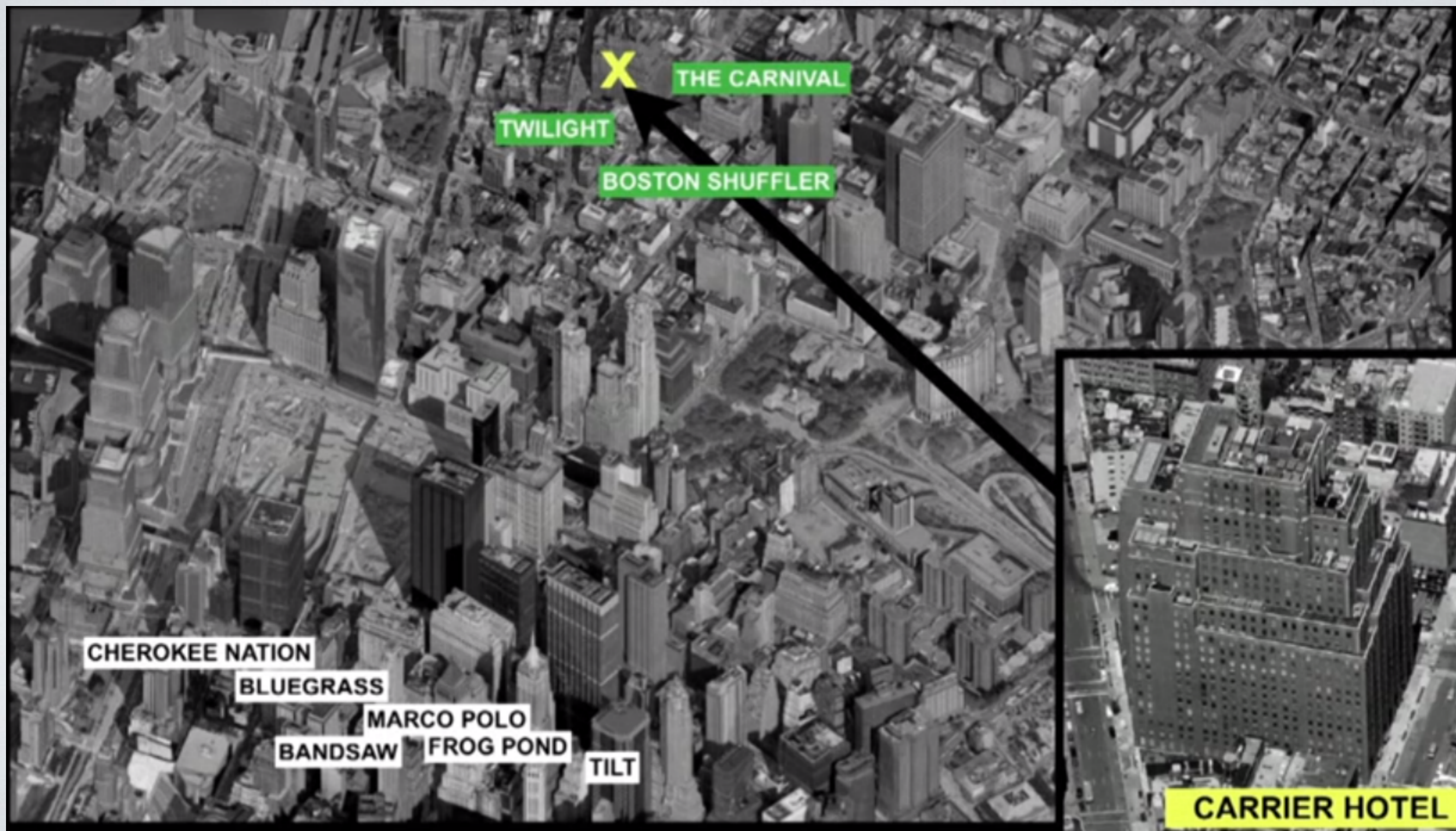
- Option 1 - Pay a dime to click on a banner on the screen 5,000 times for \$1
- Option 2 - Pay a dime to click on a banner 100 times for .5% chance to win \$5

# TRADING STRATEGIES

- Co-location: “locating computers owned by HFT firms  
in the same premises where an exchange’s computer servers are housed” for faster access to the data



# IN NEW YORK CITY





# FROM NEW YORK TO CHICAGO



13.3 MILLISECOND ROUND TRIP



# BENEFITS

- Liquidity / but they only work in highly liquid markets
- Fast: small returns x many times





# LIMITATIONS

- AI is excellent at finding patterns, but alpha comes from extrapolating patterns into insights and applying that to other areas which AI is not yet sophisticated enough to do.
- Time



# HISTORY OF CRASHES

# CRASH CANDIDATE

Down crash candidate the stock price change has to satisfy the following conditions:

- it has to tick down at least 10 times before ticking up
- price changes have to occur within 1.5 seconds
- price change has to exceed -0.8%.

Up crash candidate, the stock:

- it has to tick up at least 10 times before ticking down
- price changes have to occur within 1.5 seconds
- price change has to exceed 0.8%



# QUANT QUAKE

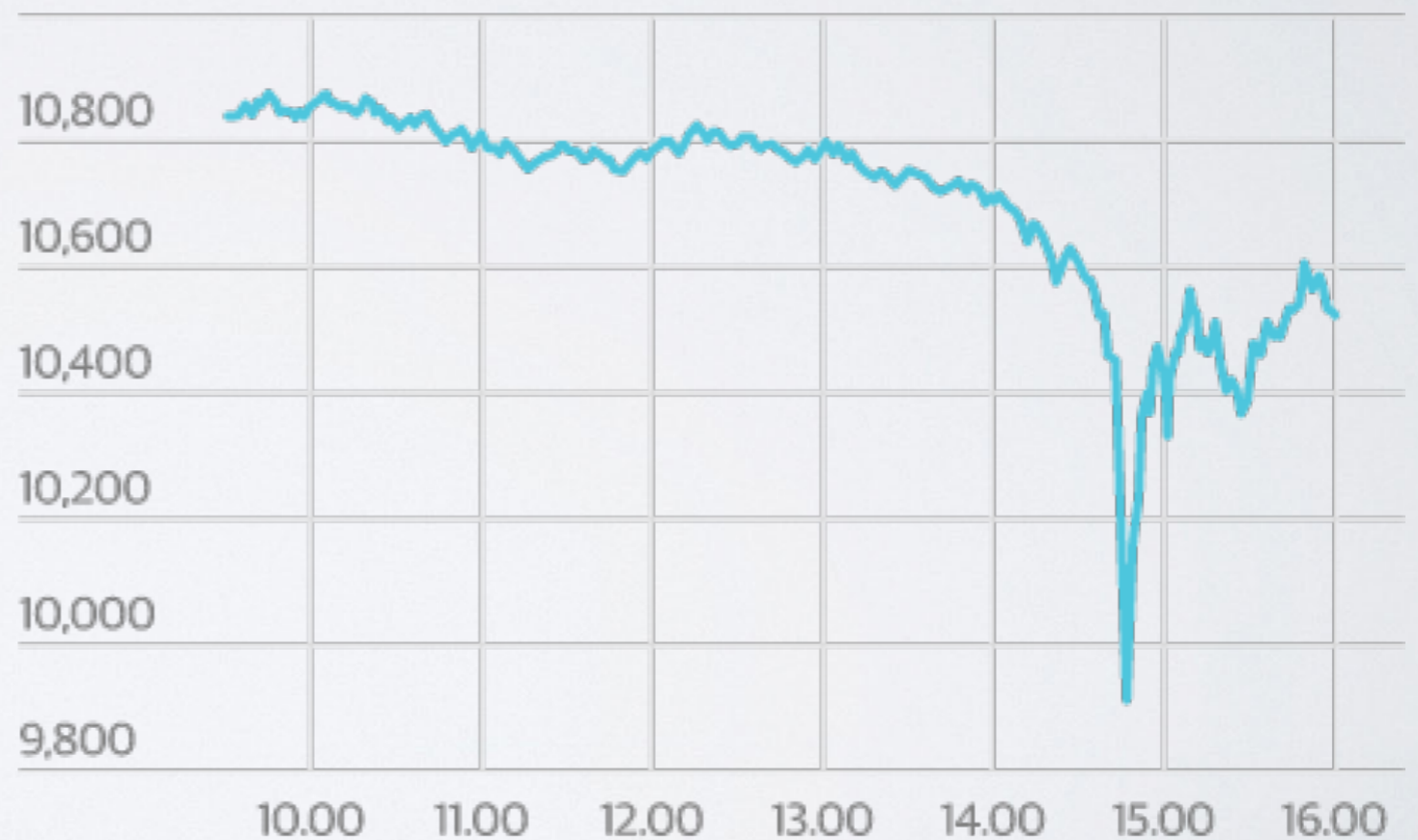
- Or “Quant Meltdown”
- When - August 6-9, 2007
- S&P 500 lost 3% in one day.
- Hedge funds and proprietary trading desks lost between 10-30% of value in that week.
  - Most of the damage was among quantitatively managed equity market-neutral or “statistical arbitrage” hedge funds.

# FLASH CRASH

- May 6, 2010 - 1:32 pm
- Lasted for 33 min.
- Dow Jones drops 560 points in 4 Minutes!

**The Dow Jones flash crash**

Index



Guardian graphic

SOURCE: CNN MONEY



# FLASH CRASH

- FTC concluded not a single organization's failure
  - “Seemingly unrelated activities across different parts of the financial system that fed on each other to generate a perfect financial storm.”
- Takeaway - there is no single “culprit” that can be punished for this, nor any new regulation that can guarantee such an event will never happen again.

# FLASH CRASH

- On April 21, 2015, the U.S. Department of Justice filed charges against Navinder Singh Sarao, a British national.
- The criminal complaint was made with the CFTC
  - Alleged that Sarao had attempted to manipulate the price of E-Mini S&P 500 futures contracts on the Chicago Mercantile Exchange (CME)
  - Specifically using the tactic of “spoofing,
  - Sarao allegedly used a financial innovation called “dynamic layering,” reportedly convincing an automated trading software company to customize his software to submit orders to give the illusion of a deep market before they were canceled.



# FACEBOOK IPO

- May 18, 2012:
- Over \$18 billion in projected sales, but instead the New York Stock Exchange chose to list on NASDAQ.
  - NASDAQ's IPO Cross software was reputed to be able to compute an opening price from a stock's initial bids and offers in less than 40 microseconds
- Demand was so heavy
  - It took NASDAQ's computers up to five milliseconds to calculate its opening price, more than 100 times slower than usual.

# FACEBOOK IPO

- NASDAQ's order system allowed investors to change their orders up the moment the opening trade was printed on the tape.
- These few milliseconds before the print - new orders and cancellations
  - The IPO software recalculated the opening trade price, during which time even more orders and cancellations entered its book, compounding the problem.
- Race condition
- Seventy-five million shares changed hands during Facebook's opening auction, but orders totaling an additional 30 million shares took place during this 19 minute limbo.
  - The SEC ultimately approved a plan for NASDAQ to pay its customers \$62 million for losses in its handling of Facebook's offering.



# HACK CRASH

- April 23, 2013
- It cost USD 139 billion.
- Syria hacked the Associated Press
- Just one week after the Boston Marathon bombings



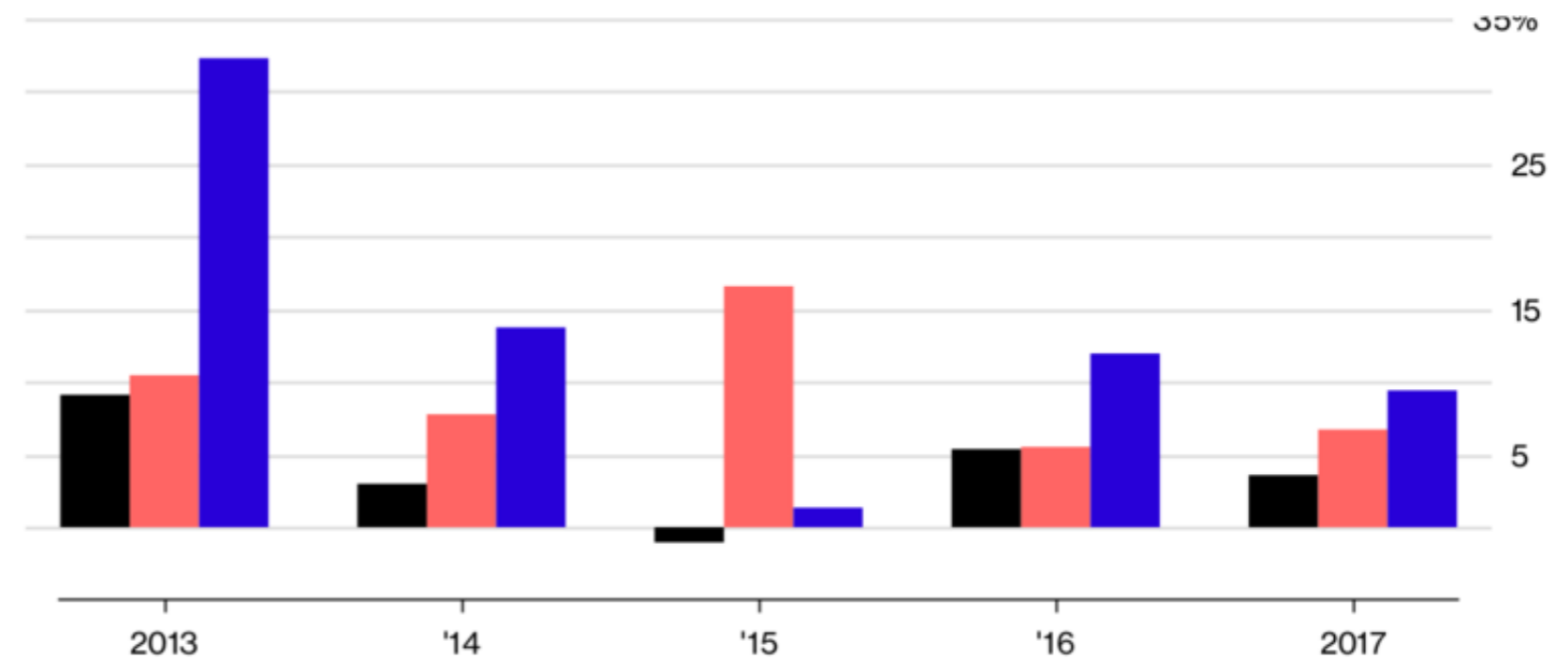
# BIG PROBLEMS - STRATEGY

- Spoofing
- Order anticipation
- Front-running
- Ticker tape trading

## Machine Learning's Gains

Like hedge funds, AI strategies have struggled to beat the stock market

■ HFRI Fund Weighted Composite Index ■ Eurekahedge AI Hedge Fund Index ■ S&P 500



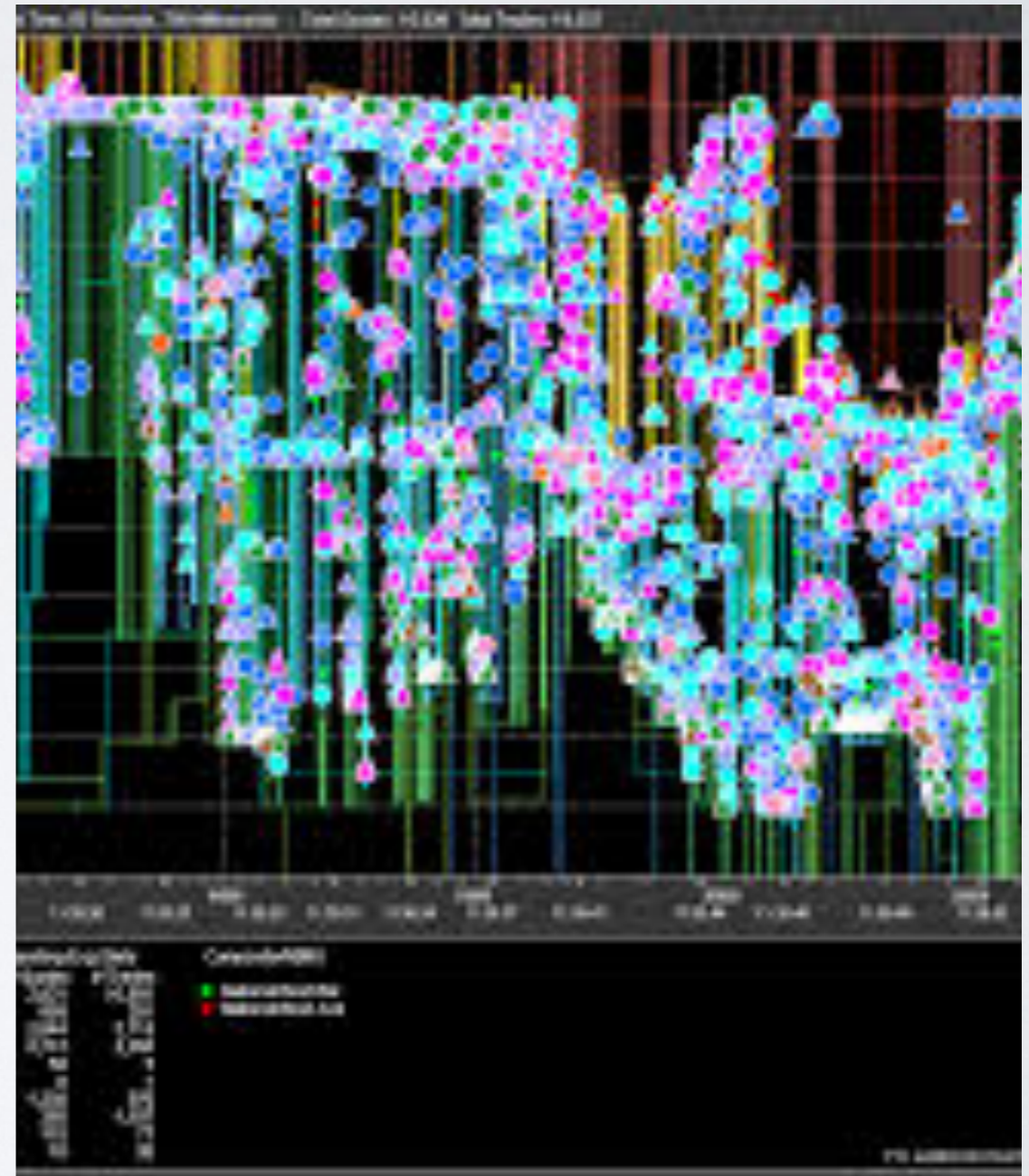
2017 returns YTD through June, S&P 500 Index returns are with dividend reinvested  
Source: Eurekahedge, Hedge Fund Research, Inc., Bloomberg

**Bloomberg**



# BIG PROBLEMS - CODE

- No proof of error free code/algorithms are not accountable.
- There is no guarantee log of all the trades. (Too fast)
- Infinite loops between HFT algorithms can go unnoticed.



# REGULATION



**Table 1** Principles of good software design and corresponding metric. Source: Li *et al.* (2015).

	Principle	Proposed Metric
1.	Conciseness: Good code should be as long as it needs to be, but no longer.	Number of words
2.	Cohesion: Modules in code should do one thing well, not multiple things badly.	Language perplexity
3.	Change: Code that exhibits large or frequent change may suggest defects.	Number of sections/ subsections affected
4.	Coupling: Modular code is more robust and easier to maintain than code with unnecessary cross-dependencies.	Size of cross-reference network core versus periphery
5.	Complexity: Code with a large number of conditions, cases, and exceptions is difficult to understand and prone to error.	Number of condition statements in code (McCabe's complexity)



# REGULATION “RULES”

- MiFID
  - In flash crashes the trading get cancelled.
  - Tick size (China 10%)
- Possible solution for spoofing
  - Time to withdraw
  - Limits of withdraw
  - Tax on trade



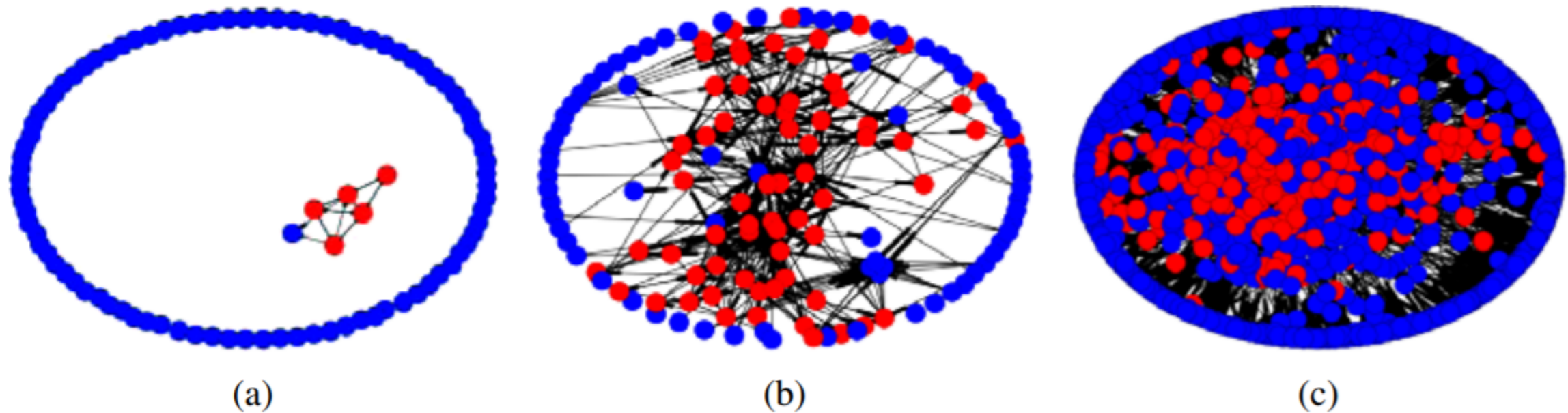


# BAD COUPLING

37 U.S.C. § 329, which describes an incentive bonus for retired or former members of the military, cites exactly two other sections, 37 U.S.C. § 303a(e) (general provisions of special pay in the military), and 10 U.S.C. § 101(a)(16) (a definition of “congressional defense committees”).

114 Meanwhile, 37 U.S.C. § 329 is cited by one other section, 10 U.S.C. § 641, which notes that other laws in Title 10 of the U.S. Code do not apply to the officers to whom the bonus in 37 U.S.C. § 329 applies.

# BAD COUPLING



**Figure 8** Core–periphery network maps of: (a) sections of the U.S. legal code modified by the Omnibus Appropriations Act of 2009; (b) sections of the U.S. legal code modified by the Dodd–Frank Wall Street Reform Act; and (c) Title 12 of the U.S. legal code (Banks and Banking). Blue dots indicate peripheral sections, red dots indicate the core. *Source: Li et al. (2015).*



# ROBOT ADVISORS

# WHAT ARE ROBOT ADVISORS?

- Use of automation and digital techniques to build and manage portfolios.
- Demand for help in “investing” and “finances.”
- Varying levels of human interaction.



# SCOPE OF SERVICES

- Comprehensive financial plans
- Providing tax advice
- Considering information about client's other accounts with other robs-advisers, etc.

# NEED FOR EXPLANATION

- Inform clients that an algorithm is being used
- How does the algorithm work and what is it used for?
- What are the algorithm's assumptions and limitations?
- What are the risks inherent in using the algorithm?
- Are there any circumstances when the rob-adviser may override the algorithm to manage client account?



# REGULATION

# GUIDANCE UPDATE

- On February 23, 2017, the SEC published a Guidance Update examining the growing industry of robo-advisers
- Offers suggestions on how a robo-adviser might address
  - Its disclosures to clients about the robo-adviser's services
  - The obligation to obtain sufficient information from clients.
  - The adoption and implementation of an effective compliance program tailored to providing automated advice.