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
  - CANTAB
  - CITADEL
  - MarkGroup
  - Winton
  - DE Shaw & Co
  - Renaissance

- **Crowdsourced quant hedge funds**
  - NUMERAI
  - Quantopian
  - Cloud9Trader

- **Online community for quant traders**
  - QuantConnect
  - TickerMachine

## Limited knowledge in algorithmic trading required

- **Algorithmic marketplace**
  - iqapla
  - ALGORIZ

- **Pure AI quant hedge fund, open to public investors**
  - Alpaca

- **Tool to optimize trading algorithm**
  - SIGOPT

- **Social trading platforms**
  - ayondo
  - collective2

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*Among other strategies

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

Etienne Brunet 2017
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.
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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

Figure 4  Financial Moore’s Law: Raw and natural logarithm of average daily trading volume by year of exchange-listed options and futures from the Options Clearing Corporation, 1973–2014, and linear regression estimate of geometric growth rate, which implies a doubling every log(2)/0.14 = 4.95 years.
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.
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 exchanges 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!
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

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

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.
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).
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?
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.