Algorithmic & High-Frequency Trading & Quantopian Company

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ALGORITHMIC & HIGH-FREQUENCY TRADING AND "QUANTOPIAN" COMPANY

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I. EXECUTIVE SUMMARY

Machines are rising. “The future will have lots of robots and few jobs for humans”, Tom Ford (2015)[1], author and entrepreneur, argues in his book “Rise of the Robots”. Robots’ learning curve is getting steeper every day in an unprecedented pace. They are extremely productive and they are becoming more complicated machines which allows them to expand their expertise areas and exceed beyond limited repetitive, routine operations.

Machines started to rise by the First Industrial Revolution back in the mid-18th century. This was the first massive replacement of “hand production” with machines mostly in the textile industry. It was followed by the Second Industrial Revolution or Technological Revolution which is characterized mainly by large-scale manufacturing plants, railroads, electrification, communication, and steam power. It started to transform from physical to digital when the third industrial revolution began; smart software with complicated algorithms for any processes of a company and robots with enhanced skills. Even if the Fourth Industrial Revolution which can be best described as “age of Intelligent Technologies” is mostly cited for the smart manufacturing environment, agriculture, healthcare, supply chain, etc, it has also very significant and transformative effects not only on the financial industry but also on the global economy.

Transforming Tom Ford’s “Rise of the Robots” to “Rise of the Financial Technologies (FinTech)” for Financial Industry would be appropriate for some reasons. It has been severely disrupting incumbents and current business models. Agility, use of new technologies and relatively low-cost solutions allow startups to overcome the entrance barriers to traditional financial

[1] Ford, Tom, 2015, Book, Rise of the Robots.

industries.[2] Even though FinTech's are spreading every segment of financial services, few of them have much been debated and criticized due to their widespread impacts and results to the global economy; Cryptocurrencies and Algorithmic/High-Frequency Trading.

Even though the Cryptocurrencies (mostly Bitcoin) has drawn massive attention with its peaks and downs during last 2 years, Algorithmic Trading and High-Frequency Trading is clearly at the forefront by far regarding their impact on the global economy and financial transformation of the industry.

Algorithmic and High-Frequency Trading has emerged where advances in computer and communication technologies meet quantitative methods in order to create new opportunities for improving and extending the application of or even developing new trading strategies.[3]

In Algorithmic and High-Frequency Trading, once it's described by hard code or make machine's itself learn in time by machine learning techniques, both investment decisions and order execution tasks have been handling by computers with ultra-low latency. These type of trading requires not only an intense investment in fiber-optic networks and computers but also high-paid skilled workforce such as Quants[4] who are the Kings of Wall-Street, skilled software programmers, network specialists, etc. By these investments, AT and HFT enable sophisticated investors to achieve tremendous profits.[5] Algorithms scan several markets at a high-speed and exploit even tiny arbitrage for the same asset traded in different exchanges.

[2] Axxsys Consulting, 2018, The Fourth Industrial Revolution: Impact on Financial Services, http://axxsysconsulting.com/wp-content/uploads/2018/03/FinTech-White-paper.pdf
[3] Mandes, Alexandru, 2016, Algorithmic and High-Frequency Trading Strategies. A Literature Review, University of Giessen.
[4] Investopedia, Quants: The Rocket Scientist of Wall Street. Quants are people who understand sophisticated mathematical models and enhance them to generate profits and reduce risks.
[5] Peter Gomber, Bjorn Arndt, Marco Lutat, Tim Uhle, High-Frequency Trading, Goethe Universitat

Advantages of these tradings are that as they are contributing liquidity to the market in a result of faster execution and increased volume of trades, BID-ASK spread narrows and markets become more price-efficient.[6] On the other hand, there are severe criticisms. The public mostly heard about HFT's on May 22, 2010, during Flash Crash of US markets. It can go out of control and cause massive crashes on markets and exacerbate volatility. Some argue that there are unfair speed and order type advantages against other investors. There are also several other drawbacks that still expected to be regulated by the SEC. The harshest criticism against AT and HFT's arose from Michael Lewis on his book Flash Boys[7]. In his book, Michael Lewis is telling a story about how a Fund Manager becomes a founder of Exchange in pursuit of preventing investors from the harms of HFT's.

Despite all of those disputes, there is a tremendous increase in trading volumes and there is an irreversible transformation towards these trading mechanisms. Thus, investors seek a way to engage in this trend. However, high investment needs and sophisticated skill-set are the main entrance barriers for those who can't afford it at all.

The problem to be examined in my paper is that will this new trading environment be only in the hands of a limited group or do individual investors have any chance to learn, create, test trade algorithms and use them in real trading.

In this point, Quantopian, a Fintech company, provides a platform that makes algorithmic trading available to everyone. For this goal, they provide learning platforms, tools, data sets, development environment and capital for successful algorithms.

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[6] What is High-Frequency Trading, https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/high-frequency-trading-hft/

[7] Lewis, Michael, 2015, Book, Flash Boys: A Wall Street Revolt

Quantopian motives investors by gamification. There's a daily contest that algorithms are competing that users of Quantopian created and they get awarded cash. So, Quantopian combined learning process with a competitive environment that pushes users to improve their algorithms. This provides a great fast-feedback feature to users. If the user's algorithm found eligible by the Quantopian Investment Team, Quantopian offers to license user's algorithm allocation. When a licensed algorithm generates profits, Quantopian splits the return between capital provider, Quantopian and Algorithm creator (User)[8].

So, Quantopian asserts to enable everyone to create algorithms and give the opportunity to get profit from it. As users do not require investment other than their time, Quantopian makes investors to overcome the entrance barriers to Algorithmic Trading.

II. INTRODUCTION

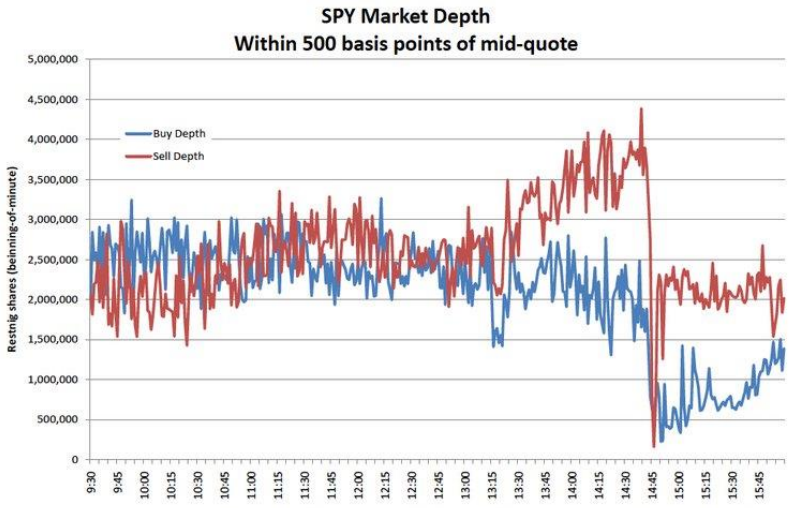
It was 2:32 PM on May 6, 2010, when the US financial markets witnessed it's heaviest selling pressure in decades. On that day, financial participants concentrated on the Greek Debt crisis, street protests over there and related effects on Euro/Dollar parity. Nobody expected a catastrophic crash resulting Dow Jones Industrial Index declined by almost 1.000 points or ~9% in a very few minutes. Hundreds of billions of dollars evaporated while some of the biggest companies' shares traded at 0.01$ per share such as Accenture, down from ~40 $ per share in a blink of an eye. Volatility jumped and liquidity got thinner. Nobody was willing to buy during those panic moments.[9] It is called "Flash Crash". A flash crash is a very rapid, deep, and volatile

[8] https://www.quantopian.com/get-funded

[9] Kirilenko, Kyle, Samadi, Tuzun, The Flash Crash: High-Frequency Trading in an Electronic Market.

fall in security prices occurring within an extremely short time period".[10] The following chart is showing clearly how S&P 500 Index moved between 2:32 PM and 3:00 PM.[11]

Also in another chart, it can be observed how the market depth of BUY and SELL evaporated in SPY (S&P 500 ETF). [12]



[10] Wikipedia: Flash Crash, https://en.wikipedia.org/wiki/Flash_crash
[11] Bloomberg
[12] https://www.businessinsider.com/charts-what-happened-during-flash-crash-2010-10

Shortly after, at 3:08 PM, almost all indexes went back to their pre-drop levels and stocks had largely recovered their losses. Due to trades during those moments, the capital changed hand. Some large and individual Investors had lost money while others made a small fortune. Even if major exchanges announced that they would cancel many of the trades during crash moments which was a controversial action[13], the flash crash took its place on the top-ranked in financial markets history.

In the aftermath, there were 2 key questions everybody were asking each other: “Why such a flash crash happened and -more importantly- would it happen again?”.

The importance of the answers for those questions is about what kind of measures and regulations to be implemented before crashes begin to shake the global economy.

There are several reasons that allegedly might cause a flash crash: Fat Thumb, Massive Sell Order for E-Mini (S&P 500 Futures) contracts [14] and Algorithmic and High-Frequency Trading.

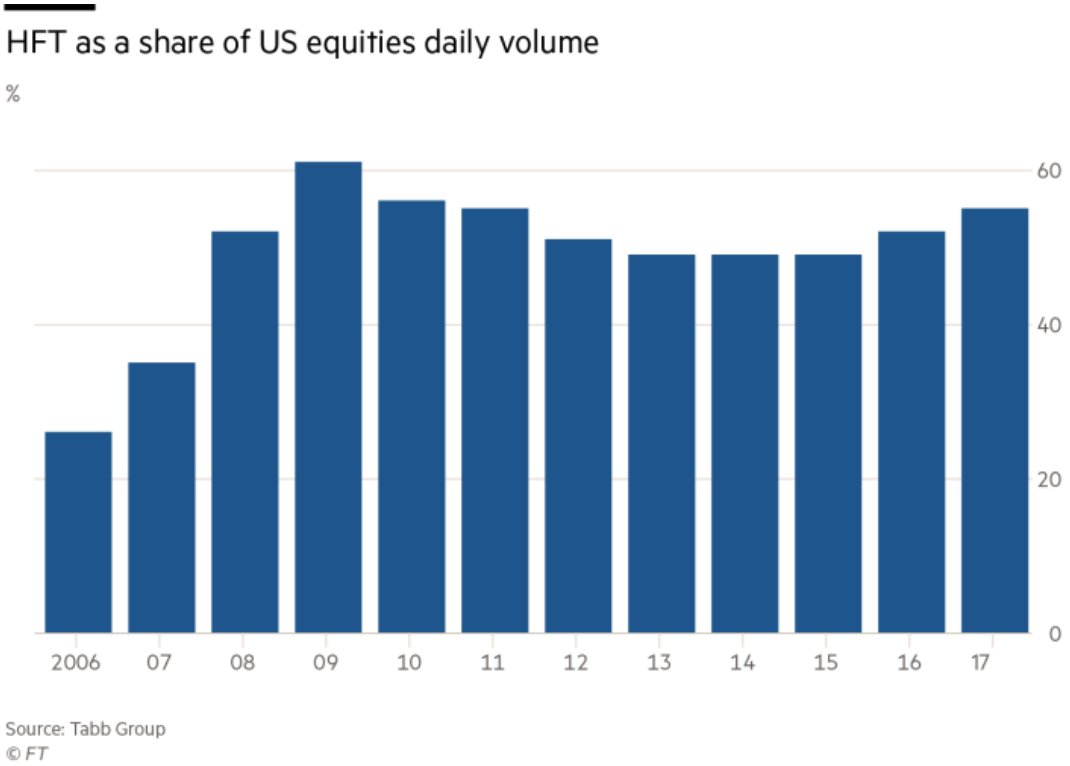
For whatever reason, there's a public consensus that Algorithmic and High-Frequency Trading had certainly a role in this case either as a trigger or as an amplifier. There were several crashes happened after 2010, however, fortunately none of them caused a severe deterioration on financial markets.

Even if society had met with Algorithmic and High-Frequency Trading through a financial turmoil, this type of investments has taken a significant part of financial markets. Large and institutional investors spent vast of their resources to fiber-optic cables, fastest computers

[13] https://www.marketslant.com/article/day-i-found-out-it-was-all-rigged
[14] Kirilenko, Kyle, Samadi, Tuzun, The Flash Crash: High-Frequency Trading in an Electronic Market.

and knowhow. They went so far that in order not to lose a millisecond, they spent millions of dollars to dig a tunnel to get a straight cable line, as Lewis told in his book.[15]

The rising share of AT and HFT in US Equities can be observed in the graph below.[16]



Starting from 2006, HFT reached over 60% of the total daily volume of US Equities. Then with Flash Crash, it declined for 4 years and again recovered to around 55%.

Also, it's forecasted in some research that algorithmic trading will have a ~10,2& CAGR between 2018-2016 and it will hit $21.807Mn by 2026.[17]

Considering the intense investments on the unavoidable rise of Algorithmic and High-Frequency Trading, the main concern of individual investors is how they possibly compete and survive in competition with those machines and brains in financial markets.

[15] Lewis, Michael, 2015, Book, Flash Boys: A Wall Street Revolt
[16] https://www.ft.com/content/d81f96ea-d43c-11e7-a303-9060cb1e5f44
[17] https://www.transparencymarketresearch.com/algorithmic-trading-market.html

The question here is that will there be any space for individual investors or will they totally get out of play and let machines manage their money without knowing what they do exactly? This is the pain-point of financial markets and investors who are eager to contribute to and profit from capital markets.

In order to fill that gap in the investment area; even if they can't compete with their computerized rivals in terms of speed, there are some fintechs come up with the idea that individuals can still learn how to create trading algorithms and put them into action in financial markets through several and structured steps.

Quantopian is one of that fintech that this paper intends to examine its business model including offerings, teaching methods, and revenue model. To introduce shortly, *Quantopian provides free education, data, and tools so everyone can pursue quantitative finance and members license their algorithms and share in the profits*.[18]

Such a platform also provides a space for those who are collectively interested in the same topic and learn from each other. Quantopian uses "Gamification method"[19] in order to keep its users continue to learn and contribute by contests every day.

With the developments such kind of fintechs, individuals will feel more secure to enter into the financial markets and contribute to the market quality. Most probably, we will see more Fintechs like Quantopian in the near future in the "Quant Land".

[18] https://www.quantopian.com/home

[19] Gamification is the process of taking something that already exists – a website, an enterprise application, an online community – and integrating game mechanics into it to motivate participation, engagement, and loyalty. https://www.bunchball.com/gamification

III. DEFINITIONS

After a brief introduction, we begin with definitions to be used in this paper. This list of definitions can also be considered as a list of keywords for those who are interested in this area as either an investor or researcher.

- Electronic Trading: Electronic trading is an electronic platform to trade financial assets utilizing a computer and network technology, gathering buyers and sellers on the same venue who are willing to trade in a virtual environment, rather than a physical floor. Thanks to its advantages over traditional floor trading, it got popular over the years. NASDAQ is the first electronic stock exchange.
- Market Microstructure: Market microstructure is the study of financial markets and how they operate[20]. It is concerned with the details of how exchange occurs in markets and consists of rules, fairness, success, failure and the design of the market.
- Quantitative Trading: It is an extremely sophisticated area of Quantitative Finance which is the implementation of trading strategies in a systematic manner. [21] The model consists of 4 steps; Strategy identification, Strategy backtesting, Execution systems, and Risk management. [22]
- Quant: It is short for Quantitative Analyst. Quants are skilled at advanced mathematics, statistical and computer programming. Their role is basically to develop complex trading models.[23] Scott Patterson who worked as a financial reporter at Wall Street, calls them as “Math Whizzes” in this book, “The Quants”.[24]

[20] Robert Kissell, 2014, The Science of Algorithmic Trading and Portfolio Management.
[21] https://www.quantstart.com/articles/Beginners-Guide-to-Quantitative-Trading
[22] https://www.quora.com/What-is-quantitative-trading
[23] https://whatis.techtarget.com/definition/quant-quantitative-analyst
[24] Scott Patterson, 2010, Book, The Quants.

- Algorithmic Trading (AT): It is also called automated trading. It uses software that follows pre-defined rules and instructions to trade. Rules and instructions consist of price, quantity, time, volatility, technical analysis parameters, and sophisticated mathematical and statistical models.
- High-Frequency Trading (HFT): Based on algorithms, HFT is a platform that executes a large number of orders within milliseconds to several exchanges.
- Market Making: It is an activity of buying and selling securities for its own account aiming to get profit from the BID-ASK spread. The main benefit a market maker provides to the system is liquidity. A market maker is generally an individual market participant or a member firm of an exchange.[25]
- Trade Matching Engine: Software that matches Bids and Offers to execute the trade. The common algorithm used in exchanges for matching is "Time Price Priority".[26] It prioritizes the orders with the best prices (Price Priority) and considers the time stamp of the order placed to execute and give them a priority for execution.
- Co-location: Locating computers of HFT companies to the nearest place to the servers of exchanges. The aim of co-locating is reducing the speed of transmitting the data from HTF's computer to the servers of exchanges.
- Latency: The time elapses to transmit the data to its receipt.
- Front Running: It involves a HFT firm racing ahead of a large client order on an exchange.[27] As explained in Lewis book Flash Boys, it's nearly impossible for a traditional trader to execute an order with a price that he/she sees on her terminal

[25] https://www.investopedia.com/terms/m/marketmaker.asp
[26] http://www.marketswiki.com/wiki/Trade_matching_engine
[27] https://www.trade2win.com/articles/2244-youd-better-know-your-high-frequency-trading-hft-terminology

Because HFT firms notice that large order and act before the traditional trader and thus prices change at a loss of traditional trader.

- Scalping: It's a trading strategy that most HTF's apply which involves profiting from very tiny price changes. Considering huge volumes that HFT's are trading, those tiny arbitrages mean big profit for HFT's.[28]
- Computer-Based Trading: It refers to the implementation of trading strategies by extremely fast submission, cancellation, and execution of orders via computers.

IV. EVOLUTION OF TRADING

Starting from bartering goods and services in the early stages of human communities, trading reached a very high and super fast technological level that beyond anyone's imagination. As the advances in the computer and communication technologies combined increased needs for goods/services and appetite for profit, “trading” transformed to something more than just exchanging goods and services to meet people's basic needs. Indeed, as a term, the meaning of "Trading" still valid. "Trading is a system of bringing people for mutual benefits”.[29] Instead, the evolving term here is "Benefit's" itself seemingly. "Benefit of a person" has always been in a transforming term that could mean food or tent for a man lived centuries before, however, a bank account with millions of dollars or a villa with a private pool for a modern community. Trade before civilization was relatively in a small circle. In a small group of people, there was bartering for food and hunting equipment, relatively in a short distance due to lack of transporting facilities.

Between 17.000 BC and 9.000 BC, developments in agriculture, farming equipment and transporting facilities led long-distance trade. Increasing production led surplus in goods and

[28] https://www.investopedia.com/terms/s/scalping.asp
[29] https://www.quantinsti.com/blog/evolution-trading-barter-system-algo-trading

"merchant" took over the task to exchange the goods within the communities without producing anything.

Starting from 8.000 BC, people had been getting mastered in farming, domesticating animals and utilizing them in farming. Trading was maturing and the world was becoming smaller as merchants could reach longer distances in the world. Types and volume of traded goods expanded to salt, copper, pottery, livestock, etc.

With the invention of the wheel, now, transporting both people and goods to another place became easier and shorter in time ever than before. Thus, the invention of the wheel represents a breakthrough of trading.

Since then, technological and methodical advances in both production, storing and transporting gain speed at an unprecedented pace. Today, anyone can purchase an item from a seller who's in other continents in a few minutes using computers on the internet.

When it comes to Financial Asset Trading, it was Venetians first traded securities in the 1300s and Belgium established the first stock exchange in 1531. There were brokers and lenders to trade debt securities. Then, in a natural risk hedging behavior, ship owners who seek profits in voyages wanted to involve investors in order to share both profit and risks of voyages. They were willing to share the risk of losing money due to pirate, weather conditions and poor navigation, in return allocate profits if the voyage was successful. Then, the stock started to issue and paid dividends. After years of development, the London Stock Exchange established in 1773. Until the establishment of NASDAQ, all exchanges needed a physical space that gathers buyers, sellers, and brokers. Trading had been executing by shouting to each other.

In the early 1970s, Electronic Communication Network was founded which allowed brokers to trade after regular trading hours. Then in 1970, NASDAQ was founded. This is accepted as a milestone as its the first creation of electronic stock market ever. Computerization of the order

and information flow introduced by DOT which stands for Designated Order Turnaround System.[30] It allows orders transmitted immediately to the specialist in the exchange and executed quickly.

As the rise of Electronic trading continued in the 1980s, Bloomberg terminal played a significant role in this era which allows brokers and big investors to see real-time market data.[31]

Trading started to shift to online trading in the second part of the 1990s since the internet intensely spread to the world. The invention of Online trading allowed even small investors to see real-time pricing like brokers. The increasing participation of people to the financial markets made volumes increased and the depth of the market improved.

Computerized trading started to take flight after by the late 1990s, as NYSE introduced several systems that allow limit orders automatically executed.[32] This is the beginning of the end of the traditional trading floor system. Human traders have been disappearing over time as the computer-driven decision-making process and execution systems evolved which is called Algorithmic Trading. In this type of trading, a human is only responsible for creating trading algorithms and building the hardware and communication facilities. All else is handled by computers with no emotion in trading that lead human to make mistakes. It can be said that all related trading activities such as market making, order anticipating, intraday trading and value or momentum have been reshaped as this new trading technique relying on ultra-speed and ultra-low-latency competitive advantage. [33]

[30] https://medium.com/rialto-ai/beginnings-of-algorithmic-trading-19eccce902a1
[31] https://medium.com/rialto-ai/beginnings-of-algorithmic-trading-19eccce902a1
[32] Goldstein, Kumar, Graves, 2014, Computerized and High-Frequency Trading
[33] Goldstein, Kumar, Graves, 2014, Computerized and High-Frequency Trading

Now, Algorithmic Trading and its sub-group High-Frequency Trading has been prevailing the markets. As can be observed in the graph below, by 2016, ~70% of Equities traded by computers through algorithms where FX trades reaches ~30%. US markets are the most adaptive to algorithms than the rest of the world. [34]

Even though the sharp rise of the market share has lost momentum for financial assets for the last couple of years due to increasing cost accompanied by declining profits[35], market participants monitor closely the advances and regulations expected to be placed in Algorithmic and High-Frequency Trading.

V. ALGORITHMIC TRADING & HIGH-FREQUENCY TRADING

Algorithmic Trading is basically a type of trading that applies "Trading Algorithms". Trading algorithms are consisting of a pre-defined set of rules and instructions based on price, time and quantity. Once the algorithms are created, there's no interaction or intervention during trading decision-making and execution process. Since no human can compete with any

[34] https://www.zerohedge.com/news/2018-12-22/deutsche-bank-lists-top-30-risks-market-2019-and-one-surprise

[35] Goldstein, Kumar, Graves, 2014, Computerized and High-Frequency Trading

computer regarding speed and ability to omitting emotions -which leads people to make a wrong decision under intense stress moments-, the role of a human in trading is shifting from traditional trading to designing platforms, creating algorithms, technological developments and -still- management and marketing. Also, algorithms need to be tweaked over time by high-skilled quants. This is not only because the marginal profit per trade is so narrow and firms should keep themselves ahead as the competition is very intense in creating alpha, but also prevent themselves from huge losses.[36] Firms are investing millions of dollar to superfast computers, private fiber-optic networks, high-paid skilled quants and extreme renting fees to get a place closer to exchange because the potential profit is so high.

TRADING STRATEGIES

Although there are different classifications in literature, I combined most of them into one list.

a. Order Slicing: This strategy aims to minimize the market impact during executing of a large buy or sell order. Instead of placing the large order at once and signal the market the intention, the strategy involves splitting the order into slices. Splitting strategy can be varied. It can be either Time Weighted Average Price (TWAP) or Volume Weighted Average Price (VWAP). In the first, algorithm split the order into equal time intervals in a given total time period; for example, in 1 hour, total order to be split into 6 slices and executed in every 10 minutes. In the second, algorithms use past volume data and determine the order volume according to the given percentage rate of total volume traded at that moment.
b. Automated Liquidity Provision or Market Making: Today's market-making activities done by machines and algorithms instead of human traders. This transformation triggered by

[36] https://traderhq.com/introduction-algorithmic-trading/

the need for speed for portfolio risk models and pricing.[37] Even though there are different investment horizons for market makers from intraday to the long horizon, the need for running risk model calculation and related execution is a mutual requirement. Algorithmic trading makes it possible to act on time for a market maker.

c. Momentum-based Strategies: Momentum investing is to define first the particular trend of a market and assume that it will continue in the same direction, then to follow it and finally evaluate every change in the market as a turning point for the trend and act accordingly. Algorithms that following those steps by using statistics is called Time Series Momentum strategy.

d. Dollar Cost Averaging: It is investing an equal certain amount of money in a periodic manner. Rather than investing all money at one time, in the long run, research indicates that this type of strategy allows an investor to have a lower cost of investing.

e. Day Trading Automation: Day trading is an exhausting activity for a human in terms of physically and mentally. As emotions involve as the market fluctuates, humans can make very costly bad decisions. Instead, defining a mechanical set of rules, this type of trading can easily be automated through algorithms. These rules are mostly based on technical indicators such as momentum, relative strength, and other indicators.

f. News/Event-Driven Trading: The day these lines are written, Trump tweeted about trade with China. Markets reacted sharply. In such kind of news or events, only the traders first identify the news is good or bad and act will win. Once the keywords and binary options are described to the computer, algorithms will act faster against any human trader. This type of strategies is called news/event-driven trading.

[37] https://medium.com/automation-generation/ultimate-list-of-automated-trading-strategies-you-should-know-part-1-c9a333f58930

g. Using Machine Learning: *Machine learning is the scientific study of algorithms and statistical models that computer systems use to effectively perform a specific task without using explicit instructions, relying on patterns and inference instead.*[38] This technology allows algorithms to learn from the new data they retrieve and improve themselves.

h. Portfolio Rebalancing: As portfolio managers diversify their portfolio on several asset classes and particular securities in order to create alpha while sustaining an acceptable Sharpe ratio, an algorithm can easily assess hundreds of securities for their risk and return profiles very fast and error-proof.

i. Pairs/Long-Short: Pairs trading is one of the market neutral strategies which involves a long and short position together on highly correlated two stocks. The main idea is that if the price ratio of two stocks diverges from the historical average, it is assumed that the price ratio will converge back its historical mean. Well defined algorithms can easily find and execute the trade on those pairs.

j. High-Frequency Trading: High-Frequency Trading, on the other hand, can be considered a high-speed and low latency technology that allows trading algorithms to submit and execute at fastest speeds and highest frequencies ever. The strategies for HFT's shouldn't be considered new. As its main advantage is low latency, HFTs are mostly utilized for tradings for very short periods and higher frequencies. Mostly the strategies are intraday and the positions are closed at the end of the trading session. Mostly used for the Automated Liquidity Provisions, Market Microstructure trading, event arbitrage, and statistical trading strategies.

[38] Wikipedia, https://en.wikipedia.org/wiki/Machine_learning

PROS AND CONS OF ALGORITHMIC TRADING

The first thing we should list as an advantage is machines don't have emotions. There's a common understanding that emotions are against rationalism when making a decision about investing. Regardless of this is correct or not, it’s obvious that machines follow the rules and instructions strictly once they have been defined in a very disciplined manner. Not only emotions are omitted but also human errors such as "fat thumb phenomenon” are eliminated in algorithmic trading. Another advantage is that machines don’t have working hours or other resting times like humans except for maintenance, software updating or hardware upgrading operations. So, trading algorithms can easily monitor markets and execute orders 24-hours a day that any human trader can do.

Machines are faster in making decisions and executing orders than any human. Also, algorithms can scan several markets in order to catch even very small price volatility.

On the other hand, there are several concerns and criticisms about Algorithmic and High-Frequency Trading. The major one, as in his book Flash Boys, Michael Lewis explains deeply is Ghost Liquidity. As the cancellation of orders became possible, the liquidity of passive orders are temporarily existing and whenever any trader try to execute a market order, they disappear. Because that orders belong to High-Frequency Traders and they disappear immediately whenever any other trader wants to place a market order. So the main argument in favor of Algorithmic and High-Frequency Trading is under heavy criticism by the opponent of this technologic trading types. Other and -actually- most popular concern which made High-Frequency Trading very popular is Flash Crashes. The most known one was on May 6, 2010, and lasted only for 40 minutes. However, 40 minutes were enough to prove its destructive effect on the financial markets. Everybody understood how can the most prominent advantage could become an uncontrollable greatest threat; speed and high-frequency. This

features can easily become an amplifier in case any slight change in the market triggered by any big news/events or big selling order by one investor. This kind of flash crashes makes investors lose their faith in markets as volatility hits their profits and lose their hard-earned money in seconds. As investors feel "unprotected" from unemotional machines, they tend to get away from the financial markets.

OPPORTUNITIES FOR INDIVIDUAL INVESTORS

The other way for an individual investor other than getting away from markets is trying to be a part of this newly emerging investing era. However, the big question is that how can an individual investor can compute with high-speed machines and talented quants?

Algorithmic and High-Frequency Trading was accepted only for institutional or big investors. It is clear that HFT is not possible and feasible for any individual investor as it requires huge investments as of today. However, developments of open source and data culture, cloud computing and basically internet created an environment that anyone with a computer can get involved algorithmic trading thanks to online platforms provided by Fintechs. And now, those fintechs made it possible for an individual to create an algorithm that -for example- buys 100 shares of Amazon when it hits 1 year low and then give an order to sell it 5% higher full-automatically.

For sure, even though it sounds very exciting, anyone should pass through some learning processes such as financials, strategies, statistics and programming language. **The pain point here is the difficulty for an individual to decide where to start: which programming language to be learned, how deep to be dived in statistics and financials, in which platform to put the algorithm in action.**

Fintechs such as Quantopian come up with an idea to help beginners to become an algorithmic trader by providing them a platform that investors can learn, practice and put their algorithms

in action. They provide to its users what they need to learn from scratch. It is clear that to go further in algorithmic trading, anyone should go beyond the scope of one single Fintech solution. To enlarge the vision, there are lots of other services or Fintechs around to be examined. There are already several fintechs in a wide range. They are ranging from only serving as an education center to providing funding to trading algorithms. To be equipped with profound knowledge and expertise, one should visit and benefit from most of them.

VI. QUANTOPIAN: BECOME AN EXPERT IN QUANT FINANCE[39]

Boston-based Fintech **Quantopian** is a crowd-sourced investment management firm founded in 2012 by two entrepreneurs and also received funding by some of the famous capital ventures such as Andreessen Horowitz[40]. Basically, Quantopian helps people to write trading algorithms and get funded for their successful strategies. Quantopian is not providing High-Frequency trading feature, however, it focuses on Low-Frequency Trading on minute-level at fast. In the web-based platform, professionals and non-professionals can write, backtest and get funded for their algorithms for US Equities and futures.

In order to do that they provide "Education, Data, Research Environment, Development Platform and Capital". The most exciting incentive is that investors get paid based on their performance of trading algorithms that fit Quantopian's investment strategy.[41] Also, the daily contest is a powerful feature to retain investors to keep creating algorithms. Quantopian has a huge community that let investors learn from each other and collaborate. There are currently over ~230.000 members including finance professionals, scientists, developers, and students. The distinctive feature for Quantopian is that any algorithm creator can invite

[39] This section uses the information provided on https://www.quantopian.com.
[40] Andreessen Horowitz: https://a16z.com/portfolio/
[41] https://www.quantopian.com/about#company

other's to help him/her to improve the code. In a highly secretive world of algo's, this can be considered as the power of open-source and creating a collaborative environment.

Members are benefiting from Quantopian for free. The platform, education, and data are free to use including +8000 US Equities and Futures. Only some datasets are based on subscription. Investors are owning their own created trading algorithms. Quantopian provides secrecy and protection about investors' intellectual property and all other data. Quantopian provides neither investment advice nor brokerage services.

The revenue model of Quantopian is based on mutual interest and benefits with members. Members are highly incentivized to create successful strategies through awarded contests and get funded if they prefer. Quantopian -as an investment management firm- invest its funds to top-performing strategies that created by members.

Once members learn how to create strategies on Quantopian platforms, they enter into a daily contest to see how the trading strategy performs. There are structural and risk criteria that every strategy has to have to pass the first step of the process. This step is important for getting feedback without losing money. If the strategy performs well for at least 6 months, Quantopian evaluates the strategy based on criteria, track record and backtests. Then Quantopian offers members to invest capital and members share net profit for the algorithm when the licensed algorithm generates profits. The offer is 10% to a member whose algorithm is selected. According to the Efi Pylarinou, a Fintech thought-leader, 10% is above the average bonus of a proprietary trader and lower than hedge funds.[42] Of course, this process is subject to member's consent and members are always free to reject the offer.

[42] https://dailyfintech.com/2017/05/30/fintech-solutions-in-quant-land-quantopian/

Quantopian’s funding process consists of several constraints. For example, algorithm strategy should trade on liquid stocks and cannot invest more than 5% of the capital in one asset. In terms of dollar exposure, the maximum limit of exposure is 10%. It means, the difference between Short and Long position should not exceed 10%. When it comes to leverage, the allowed range is 0.8x – 1.1x (or 80%-110%). There are some other risk constraints defined in detail that members should obey.

The evident question here is why any member with an algorithm that generates profit, wants to share the profit with Quantopian and its investors. Firstly, members are free to reject the offer made by Quantopian and apply their strategy by their own in any other trading platform. However, there are several quite strong incentives that encourage members to accept the offer. The most important one is there is no downside risk for the member if the algorithm doesn't work in real life. If the algorithm loses money, all the loss will be beared by Quantopian. So members are investing equities with risk-free. The other part is about the operation. All the trading operations are managed by Quantopian. This allows members to focus on creating new algorithms or developing current ones instead of handling daily operations of trading. Last but not least, members don't need to seek capital as Quantopian provides the capital.

USING QUANTOPIAN

a. Learn

The first thing anyone should do learn about data science for quantitative finance through tutorials and lectures provided by Quantopian. It covers the topics about Quantopian's API, Python programming, Data Exploration, Strategy Analysis, Portfolio Construction, and Backtest Analysis. Also in lectures, there are numerous topics for quantitative analysis such as

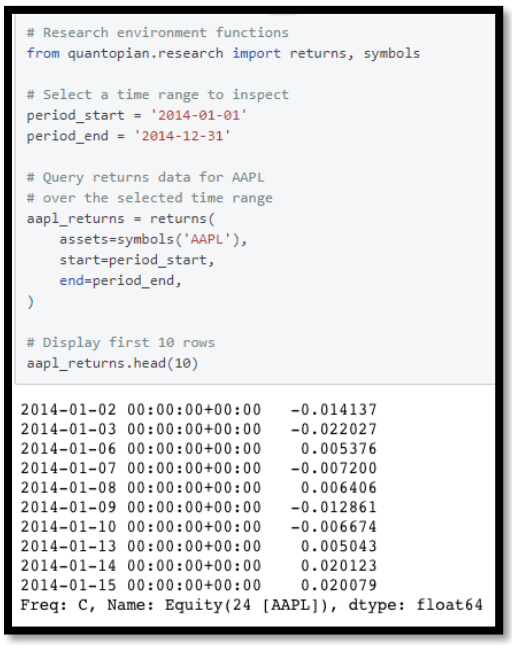
mean, variance, regression, confidence intervals, portfolio analysis beside investment strategies like pair-trading. These tutorials and lectures are designed structural that assist members where to start and what to continue.

Also, Quantopian initiates a program for professors to teach students how to create trading algorithms. This program is created in collaboration with professors at Cornell and Harvard.

b. Research

After getting the basics, the next step is creating a trading strategy. It is said that 90% of the time spent is for researching an idea and only 10% is for coding it for a quantitative investor. Members can create a strategy from scratch or copy and tweak any strategy from the database. Quantopian Research platform provides both datasets and analytical tools. In the Research area, members can create queries about pricing, volume, and returns for thousands of equities.

The picture below demonstrates an example of a query about the first 10 rows of returns of APPLE for the year 2014.



```
# Research environment functions
from quantopian.research import returns, symbols

# Select a time range to inspect
period_start = '2014-01-01'
period_end = '2014-12-31'

# Query returns data for AAPL
# over the selected time range
aapl_returns = returns(
    assets=symbols('AAPL'),
    start=period_start,
    end=period_end,
)

# Display first 10 rows
aapl_returns.head(10)
```

```
2014-01-02 00:00:00+00:00   -0.014137
2014-01-03 00:00:00+00:00   -0.022027
2014-01-06 00:00:00+00:00    0.005376
2014-01-07 00:00:00+00:00   -0.007200
2014-01-08 00:00:00+00:00    0.006406
2014-01-09 00:00:00+00:00   -0.012861
2014-01-10 00:00:00+00:00   -0.006674
2014-01-13 00:00:00+00:00    0.005043
2014-01-14 00:00:00+00:00    0.020123
2014-01-15 00:00:00+00:00    0.020079
Freq: C, Name: Equity(24 [AAPL]), dtype: float64
```

Members are not limited only with market data but also they are able to reach additional datasets covering corporate fundamentals, stock sentiment analysis, macroeconomic indicators, and further 50+ datasets. Members try to search for patterns and aiming to find meaningful strategies they believe to work.

After managing to access and manipulating the datasets, members define their trading strategy. For example, a member who creates “Long-Short Equity Strategy” will do some analysis for constructing the portfolio or deciding which equities to be picked for short and long.

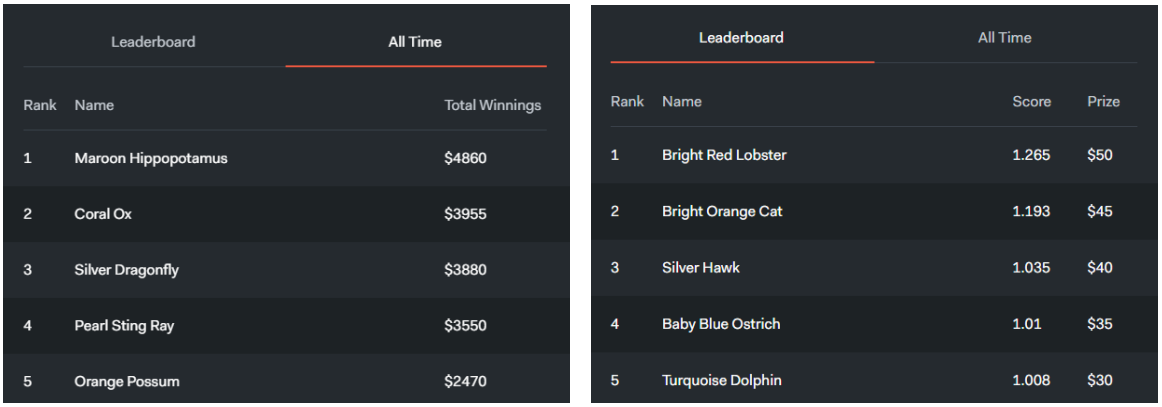
Then, the member will move to the Development Environment of Quantopian to build the trading algorithm. Once the algorithm built, members analyze the algorithm's performance simulating with historical data. This is called Backtesting. In constructing a portfolio, in order to limit risk exposure, some risk measures and limits are identified in a risk management standpoint.

For sure, all those steps are very detailed explained with examples. Also, it requires quantitative analysis and coding knowledge. In order to warm up to the subject or to get familiar in the early steps, members can copy and try to understand current codes and strategies given for practice. And by changing the parameters, they can easily understand the effects of parameters already defined in the strategy.

c. Contest

After writing the algorithm, it comes to compete with other members. There's a daily contest that member enter and top-performers win prizes. The scoring model is based on the last 63 trading days and volatility measurement. This part is mostly for tracking the performance, getting feedback about the algorithm and improving the performance as the prizes are only

at consolation-level; total cash prize for every month is only $5.000 and distributed to many members. This king of gamification provides a significant motivation for the members and a great tool to ensure members' permanency. Entering in the contest is also compulsory because every algorithm has to pass 10 structural and risk criteria that "The Contest" requires in order to get funded. In the tables below, we see top-performers of the day and "all time".



Leaderboard | All Time

Rank	Name	Total Winnings
1	Maroon Hippopotamus	$4860
2	Coral Ox	$3955
3	Silver Dragonfly	$3880
4	Pearl Sting Ray	$3550
5	Orange Possum	$2470

Leaderboard | All Time

Rank	Name	Score	Prize
1	Bright Red Lobster	1.265	$50
2	Bright Orange Cat	1.193	$45
3	Silver Hawk	1.035	$40
4	Baby Blue Ostrich	1.01	$35
5	Turquoise Dolphin	1.008	$30

d. Get Funded

After testing enough to provide the evidence that the algorithm will continue to make money in the future, Quantopian's investment team evaluating it whether it fits their portfolio. If so, Quantopian offers to license the algorithm for allocation. When licensed algorithm generating profits, the profits split between providers of capital, Quantopian and algorithm owner.

As of June 1, 2018, $155MM is allocated to algorithms and $52.9MM is allocated to a single algorithm.

MY EXPERIENCE WITH QUANTOPIAN

I subscribed to Quantopian and already started to learn how to create an algorithm from scratch. I get excited when I first navigate the website, it makes me feel comfortable in the sense that I can learn anything I'll need from this platform and can create my first algorithm. Because I find the learning tools are really comprehensive for a starter and it provides further

learning materials such as lectures. And knowing that I can advise to other members about anything motivates me on spending time on this. Another strong feature I like is gamification through "The Contest". Even if I cannot create successful algorithms, at least I can compete with others and improve my skills quantitative and coding skills. It is good to know that Quantopian provides everybody the same equal opportunity to get licensed and funded. Beyond all, it would be great to succeed to get funded. I think this is the most powerful feature to help members learning motivation alive and learning curve steeper.

VII. CONCLUSION

In a modernized world, people are making all their efforts to create robots that will perform the tasks which they have to do before. People not only create computers but also teach them how to behave like a human in performing such of those tasks.

In reflection to financial markets, it is crystal clear that computer-based trading is conquering the investment environment. For a sophisticated and emotionless computer with its huge computation power, it is easier to perform predefined mathematical and repetitive tasks far beyond any human’s capacity.

Institutional and big investors allocate a significant amount of resources to build algorithmic and high-frequency trading. However, small investors evidently behind the race with their modest resources to allocate.

The main argument this paper argues that small investors can integrate themselves in low-frequency Algorithmic trading even if it is not feasible and rational to race in High-Frequency Trading area.

Fintechs like Quantopian provides people a platform that they can learn, build and test their own trading algorithms which may make money. As collaborative learning becomes a common practice for communities, Quantopian leverages community-based learning in addition to its comprehensive learning tools that provide all necessary information for those who are eager to improve themselves. While gamification concept activates people's sense of competition and motivates them to keep improving their skills, Quantopian and investors give the opportunity to make real money to members by funding their algorithms and profit-sharing with zero loss-risk for members.

Eventually, utilizing the most attractive modern concepts in their business model, Quantopian is a human-centric fintech dedicated itself to be a partner of those who is willing to improve themselves. It is also proved by the numbers such as members, capital allocation, etc., there is a room for small investors to be a part of this automatized trading venues. Considering not only Quantopian but also increasing number of other Fintechs provide such platforms to members, it is a rising star for finance even though it requires sophisticated skills.

An increasing number of fintechs and interests from both people and venture-capitalists proved that it is possible for any small or individual investor can be a part of low-frequency algorithmic trading which will be mainstream for the near future.

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