**AI Killed the Banking Star**

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**Abstract:**

This paper reviews the effect that technology had on the financial industry and overall economy since the introduction of the computer to Wall Street and how the success of such technology has culminated in Artificial Intelligence (AI) being developed and used by financial institutions. It will discuss how AI is being integrated in the financial industry through various services and how these changes will affect the overall economy. The analysis will be split up into three sections: the first will give the history of technology in finance and how its effect on the economy has made it more efficient and global. The second part will give a look at what defines AI and its evolution from a purely theoretical concept to one with widespread commercial use. The final section will examine the current ways AI is being used in financial industry and the ways it will change the industry in the near future and the people they employ. It is hoped that this paper will inform people interested in finance about the growing importance of technology and specifically AI on the industry and the economy as a whole.

1. **Introduction**

Artificial Intelligence (AI) has long been considered a discipline that will relieve human of its labor, and within the past few years we have finally seen its development in the workplace. Similar to how automobiles replaced the horse, light bulbs replaced the candle, and robots took over the assembly line, it is believed that the must innate part of humans–thought–is currently being replaced by AI systems. According to analysts at McKinsey, tech firms invested between $30 billion in AI in 2016 alone, and that number is supposed to double by 2020.

The finance industry is not unique to these developments. People like to follow the money, and no one likes money more than bankers. The ability of reducing the high price of human labor in the thought-intensive financial industry with systems that can work 24/7 is appealing to executives. As a result, nearly every large financial institutions has began investing in AI to stay competitive in a rapidly changing global workplace where the role of an educated worker is increasingly meant to create automation.

The purpose of this paper is to show the benefits that increasing Artificial Intelligence in finance will have on the marketplace, specifically the breadth of clients it is capable in assisting as well its role in creating a more efficient market. Additionally, it will focus on the transformation of the finance worker from a qualitative and client focused worker who tries to make deals to a quantitative and technically trained worker whose job it is to create AI systems that will interact with clients the worker will never meet.

Due to the technical depth of Artificial Intelligence as well as Financial Technology (FinTech), this paper will have a plethora of background information. The first two sections of the analysis chapter will be dedicated to informing the reader the necessary knowledge they must know before they learn about the use of AI in finance. The first of these two sections will give a history of financial technology starting with the introductions of computers in finance, and how its path lead to where the industry stands today. The second of these sections will give a brief overview on what defines AI. The implementation of AI is only a couple decades old, however, its history dates back to World War II, and the debate on what is considered AI continues to this day. This section will help clear up the misconceptions of AI as well as provide the reader the evolution of the history of AI from being an abstract concept to a commercial product.

The final section of the paper will tell the reader the ways that AI is currently being used in finance and how each of these implementations is assisting to create an equality of opportunity in personal finance in addition to a more efficient market. Moreover, the final section will illustrate the future role of the financial institution as an architect of artificial intelligence systems as opposed to a group of intermediary deal makers.

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**II. Literature Review**

**On the History of Technology in the Financial Markets**

**Complete Guide to the Capital Markets for Quantitative Professionals**

*Alex Kuznetsov*

This book is essentially the Bible when it comes to giving information on how technology is being used by the large financial institutions. Although the book was written in 2006, prior to the financial crisis, it does an incredible job of explaining the different roles in the capital markets and the technical financial knowledge necessary in it. The second half of the book is dedicated to explaining all of the software, databases, and hardware used by financial institutions and their role in the workplace. While not referenced in this paper, its knowledge gave

## **Bank 3.0: Why Banking Is No Longer Somewhere You Go But Something You Do’**

## *Brett King*

King makes the point that we live in a world where connection is necessary in the Information Age. As a result the demands of the consumer extend to banking where there must be convenience to be able to perform mundane tasks via your computer or phone.

The first part of the book explains how banks must change in this digital age for the benefit of the customer experience which means an investment in technology instead of an investment in people. King points out that branch banking is incredibly inefficient as transportation and wait time is hours more than needs to be done. However, banks already know that branches are inefficient to the customer, but it is the only way they get revenue as offline their employees get to act as salesman whereas customers online just skip over information. In addition to having their services online, banks also compete in guerrilla marketing by improving brand name via social media. The hope is that they can get people into branches by promoting a friendlier brand image.

The second part of the book explains how banks can improve themselves to catch up with the times. One of these ways is by building digital relationships with their clients and can offer swift advice on how to improve their situation. Another way banks can improve their images is by allowing mobile payments. People love Venmo and phone commerce as it is much easier than any carrying wallet around. By promoting such apps, banks can improve their image. The book ends by saying that the increase in technology is one that larger banks will be able to adapt, but the smaller ones will not. This is because the smaller banks do not have the capital to offer large technological services to their clients.

## **The End of Banking: Money, Credit, and the Digital Revolution**

## *Jonathan McMillan*

This book written by a PhD economist and an investment banker together under the pseudonym, Jonathan McMillan is put into three parts: banking in the industrial age, banking in the digital age, and a world without banking.

The first part: Banking in the Industrial Age discusses how banking is the “creation of money out of credit”. This old-school type of banking focused on information asymmetries, credit risk, and facilitating transactions. Leverage was a big part of these banks, but in a credit crunch run on the banks happen which leave assets worth less and the system in shambles. To avoid runs, banks have deposit insurance and hold significant reserves. However, their risk profile still runs high as limited liability motivates risk taking

The second part is about how banks in the digital age are out of control. The industrial age balance sheets were easy to understand and manage accounts, however, the digital age and fancy modeling brought financial inventions and securitization of anything. Risk on balance sheets could be diminished with special purpose vehicles and structuring of assets brought asset-backed securities and collateralized debt obligations. After this fiasco resulted in a panic, regulators tried to implement zero interest rates and quantitative easing to increase asset prices.

The third part is about a world without banking. This system did not create money with credit and did not have risk insurance which in turn separates credit and money. McMillan wants a decentralized financial sector that distributes deposits in p2p lending. For example, using a debit card to buy a good would create market liquidity by looking to sell loans or financial assets of the credit card owner. Otherwise, depositing would result in finding investment opportunities to execute instantly. This new system would have two rules: one would be “the total value of the real assets has to be greater than or equal to the value of the company’s liabilities”. The other is “the value of real assets of a company has to be greater than or equal to the value of the company’s liabilities in the worst financial state”.

**Fintech – The digital (r)evolution in the financial sector**

Thomas Dapp

This is a research piece by Thomas Dapp of Deutsche Bank research who discusses how algorithm-based banking can be used with a human. Dapp concludes that the future of economic activity is digital and the digitization of business models should not be driven by IT departments, but by the company as a whole.

Dapp’s whole paper revolves around the fact that banks need to invest as soon as possible. Due to the effects of the financial crisis, changing consumer base, and harsher regulations, banks must learn how to adapt to stay on top. Dapp believes that the future is a highly internet-driven and virtual direction and that banking will “change faster over the next ten years than in the most recent decades”. He thinks that bank’s stores will either be virtual or consist of 3D avatar’s that is well versed in speech recognition and available bank information and data analysis. He also speaks at lengths about the privacy issues in banking and how people should be told whenever their personal data is collected.

Lastly, Dapp thinks that a new understanding of data is under way and handling data will be more important than ever. Internet consumers are the future and banks have to know how to handle data to appeal to these people. To do this will require extensive research and experimentation as scopes this large that deal with individual freedom have not been tried previously.

**Artificial Intelligence**

**The History of Artificial Intelligence**

University of Washington

This guide gives an in-depth overview on the history of Artificial Intelligence. The guide begins by explaining the Turing Test as the beginning of the AI field and how today it is still used as the primary test of AI. The text then goes on to explain the history of AI with regards to chess and other boardgames. It talks about how at the beginning of AI, people devised ways for a computer to play checkers, however, over time they realized the difficulty that would come beating humans at more complex games such as chess. The fact that within a 40 year time period we were able to devise system that could not even compete against elementary players to being able to defeat the best player in the world has shown how far AI research has come.

The rest of the book talks about the AI winter and how after the 50s, people thought that Artificial Intelligence was done for. However, improvements in computer hardware as well as domain specific AI and intelligent agents used for data handling has shifted our view of AI and allowed us to apply it to search engines, cars, and stock traders.

**Artificial Intelligence: The Next Digital Frontier**

McKinsey

This report done by McKinsey explains the speed at which AI is growing. Tech giants spend the bulk of money on AI (between $20B and $30B). Most of this was done on R&D, but some was done on developer acquisitions. Furthermore, McKinsey stated that it is at its infancy outside the tech sector. Fewer than 20% of CEOs have said they use AI-related tech at any scale in their business and are uncertain of the business case to use AI. Furthermore, commercial use of AI is pretty much negligible as 12% companies that use AI use it for commercial use.

McKinsey then talks about the different use of AI in different sectors. Tech, telecom and finance are the leading sectors in the adoption of AI. However, automakers are building self-driving cars and aviation is beginning to see self-flown planes.

The important takeaway from the survey is that the benefits of using AI are real if employed properly. The study concluded that early companies that invest in AI typically have the highest profit margins and largest performance gap with other firms. This means that to remain afloat in business, instant action to invest in AI is a must for firms. Likewise, the workforce must not fight AI but be re skilled to compete with it as it is inevitable that firms will be switching to AI.

**Artificial Intelligence A Modern Approach**

*Stuart Russell, Peter Norvig*

This is the AI textbook that nearly every program that offers an AI course uses. The book explains how AI is determined, the history of AI, real world application and how to implement it.

A big part of the book focuses on intelligent agents and problem-solving agents. Each of these are self-learning algorithms that can identify issues, fail, and learn from their failures until they solve a task at hand.

Furthermore, the book spends a lot of time explaining how Artificial Intelligence algorithms are faster than human implemented ones and they show this with different search algorithms. Human implemented algorithms finish sorting at O(n log n), while AI have capabilities of going faster.

**AI in Finance**

**Robo-Advisors: A Portfolio Management Perspective**

Jonathan Walter Lam

This is a paper by an investment manager at Yale University. Lam wrote on the the benefits of robo-advisors as portfolio managers.

Robo-advisors have been used since the great recession as a lower cost, passive way to invest. Passive investing has been shown to be more beneficial to the client, but less beneficial to the fund. With robo-advising, an AI system can just take the demographic information of the investor and pick an ETF with the right balance of stocks for its clients. Throughout this time, a robo-advisor will consistently monitor and rebalance the fund while keeping in mind transaction fees in order to help out the client maintain wealth.

Robo-advisors have their benefits over human advisors since they it can personalize portfolios better and is better monitoring and applying mean-variance analysis. Furthermore, they are much cheaper than human advisors and do not typically have conflicts of interest. They are also better at diversifying assets and are capable of making the right balance in the economy.

**High-frequency trading and the efficient market hypothesis**

*Gianluca Virgilio*

Virgilio contents that high-frequency trading both contributes and takes away from the efficient market hypothsis.

Virgilio contends that since they are speedy, high frequency traders can beat slower competitors in limit orders and picking off other limit orders. Virgilio performed a simulation of arbitrage opportunities and saw that few high frequency traders actually obtain risk-free return on arbitrage opportunities.

The reason why they do make the markets more efficiency is with their lightning fast discovery of price imbalances. The network of traders will quickly adjust the arbitrage opportunities back to the normal spread and price discovery will not exist anymore.

**ROBO-ADVISORS: A CLOSER LOOK**

*Melanie Fein*

Fein, a former counsel to the Board of Governors of the Federal Reserve does not believe that robo-advisors are beneficial to consumers. One of these reasons is because they are not advanced enough yet to actually personalize the identities of the investor and as those investors would be better just going with an active manager. Another reason is because they have conflicts of interests. Mutual funds are tied up with specific brokerages and securities and with robo-advisors will invest in those legally without notifying the investor what will happen. Additionally, robo-advisors are not legally required to be bound to their fees meaning they can change at anytime. This is not beneficial to the consumer, and Fein points out that most of the time a 401k has higher returns than robo-advisors solely due to less fees.

**Models of Financial Markets**

*Frederick Betz*

This scholarly article was about model analysis performed by BlackRock’s Aladdin. What Betz found was that computer-based analysis and models are vital to modern financial markets. Betz used 4 empirically based models, (financial transaction, disequilibrium financial market, disequilibrium investment bankingm and disequilibrium financial grid) all based on the Fisher-Keynes-Minsky belief that financial systems are inherently unstable.

Betz found that data mining techniques used in analytical searchers are important but do not directly make models, but rather suggest models, correlations and clusters that may occur in a model.

Betz found that financial algorithms do not capture full reality of financial grids, however, topologically the data mined and machine learning benefits of Aladdin can help it come closer.

**III. Analysis**

**Section I: A history of technology in Financial Markets**

*Reporter: Why did you decide to rob banks?*

*Willie Sutton: Because that’s where the money is.*

**Introduction:**

Becoming rich in both time and money is an innate desire. As a result, people like to maximize the efficiency to create capital gain so that they make the most money for the least possible work. One of the greatest ways to exploit the inefficiencies in market in order to make capital gains is to create the means through the latest technology to maximize the number of transactions carried out in your favor. The practice of technology in banking has lasted for over one thousand years, however, most of the field’s investment in technology has come in the last half century with the development of computers. This section will explain the history of technology in finance and will be organized in a timeline manner. Although technology has been used in finance as early 900 AD with the introduction of paper checks, for the sake of only considering modern technologythis section will begin in the 1950s with the beginning of computational finance as a discipline.

1. **Genesis of Computational Finance (1950s)**

Prior to the 20th century, banking was almost exclusively a qualitative industry that was ruled by kings, merchants, and industrialists needing to raise capital to start wars, fund trans-oceanic trade, and build factories, respectively.1,2,3 Although loan offering requires mathematical knowledge of a number of variables including inflation rates and present value, the industry was a lot more about making connections with deep pockets in order to get receive funds from M&A setups and large loan payments. The early capital markets in addition were exclusive to company owners who wanted to diversify their assets in case their business had a bad year.4 As a result of being a largely qualitative industry and technological innovation being focused to material instead of data purposes, finance used little technology besides paper until telephones became widespread in 1920s5 while the world was experiencing a credit and stock boom6.

After the Great Depression, the stock market did not go away and the worldwide focus on education, specifically in mathematics, from World War II and the Cold War brought calculus and data analytics to Wall Street. With the increased focus on data, it became necessary to be able to process it in a meaningful manner. Luckily within the previous decade people had figured out how to configure electric circuitry to process input in the form of computers. Economist Harry Markowitz was the pioneer of the new discipline of computational finance when in 1952 he hypothesized that portfolio selection could be a mean-variance optimization problem for which he was later awarded a Nobel Prize.7,8 The computers he was working with at the time did not have nearly enough computational power to solve the optimizations.9 As a result, Markowitz used algorithms that were close enough to approximate the best portfolio possible.10 Markowitz discovery of using computers to handle large amounts of financial data sparked a revolution in the industry that is still happening to this day.

**2. Quantitative Analysis (1960-Present)**

WIth Markowitz’ new financial innovation, mathematicians entered the financial industry in droves to study portfolio theory. In the 1960s, fund managers Ed Thorp and Michael Goodkin joined Markowitz and economists Paul Samuelson and Robert Merton in developing computers to arbitrage trade.11 In doing so, there became an automated way for investors to take an advantage in the different prices between markets by making deals that capitalize the difference in prices.12 Arbitrage trading has become a staple in hedge fund trading ever since, and has arguably contributed to an overall more efficient marketplace as differences in markets have been nullified by arbitrage traders attempting to maximize their profits.13

In addition to the pioneering of arbitrage trading, Eugene Fama of the University of Chicago relied heavily on computers and Markowitz’ work on optimization to discover his efficient-market hypothesis (EMH).14 The EMH states that asset prices reflect all of the public information on the asset and thus any attempt to beat the market will be futile because the inefficiencies that do exist in the market are random and cannot be discovered with the available data.15 Fama’s theory has been heavily contested, and has even been blamed for the 2008 financial crisis.16 However, despite some inaccuracies in the theory, it has been proven to be a good rule-of-thumb to follow for most investors. The EMH eventually lead to an increase in index funds and thus passive asset management, which will be touched upon in the Section III discussion on robo-advisors.

In the 1970s and 80s, computational finance largely shifted towards options pricing with the invention of the Black-Scholes formula as the standard option pricing method.17 Due to the Black-Scholes equation becoming standard, many funds brought in their own quantitative analysts to make their own models that could outperform Black-Scholes in some areas to make money for the fund.18 The highly mathematical nature of this formula as well the reduction in defense spending from the Cold War ending brought in the “rocket scientists”–some from the Soviet Union– to Wall Street.19 Many of these financial engineers had graduate degrees in Physics or Mathematics, and it was not long before they started inventing their own derivative pricing models and asset classes.

In addition to the investment friendly economy brought on by the Reagan Revolution and the introduction of personal computers, the plethora of asset classes and financial instruments that exploited inefficiencies in the market brought booms to Wall Street. At the beginning of 1980 the Dow Jones was at 867 points. By the start of new millennium that number grew to 11,722, an unprecedented 1252% increase spread out over 20 years.20 These new assets were credited with decreasing interest rates and increasing lending by financial institutions during this time period.21 However, among the thousands of derivative instruments that were created a few turned out to be poisonous. The housing industry in particular grew to astronomical levels as a result of shoddy credit keeping and the reckless belief that people could pay back mortgages that consisted of a large part of the recipient’s income. The result was an economic meltdown and a reconfiguration on how banks practice lending.22

As a result of the housing crisis, banks are more than ever relying on quantitative models to correctly assess lending and investing practices so that such a crisis will not happen again,23 while their income can still satisfy shareholder’s demand. This comes with a large price as the cost for an analyst who is technically proficient to produce such modeling is more than most employees.24 The result is banks and hedge funds are investing in large amounts so that the dynamic modeling required to keep up with market speeds can be fully automated and they can employ fewer traditional quants. This is where AI in modeling has begun and is the future in both the loan and investing divisions of banks and funds, respectively.25 Further discussion on what this entails can be found in Section III.

**3. Exchanges Go Electronic, Market Availability Grows**

One of the greatest outreach programs in terms of market accessibility that the stock exchanges performed was the implementation of electronic trading. Prior to the developed communication technology in the late 20th century, stock exchanges were centralized in location where buyers and sellers would engage in on-the-floor open outcry trading. This system relied on people to process trades and centralized traders to only a few places in the world.

The world of exchanges began its drastic change to a decentralized, global system with the opening of the NASDAQ stock market in 1971.26 Although at first it only quoted prices since the technology for e-trading did not exist yet, NASDAQ was crucial in eliminating the spread (difference between bid and ask prices) that was a barrier to many investors.27 By 1982 NASDAQ began taking over-the-counter (OTC) trades and had listed stocks on its exchange. Throughout the 1980s, the NASDAQ expanded its outreach by adding electronic trading systems and being able to execute trades via the Internet.28 The accessibility of the NASDAQ proved to be valuable to investors. In 1990 when it was still a relatively small exchange, the NASDAQ had a daily trading volume of around 200 million shares. In the next decade that number had grown to 2 billion shares per day.29 Within no time NASDAQ began passing well established exchanges in terms of size. Despite being an exchange for slightly over 30 years, the NASDAQ has the 2nd highest market cap in the world, only trailing the New York Stock Exchange.30

The addition of NASDAQ to the marketplace brought its competitors to ditch the trading floor method for a more electronic one. First in 1986, the London Stock Exchange opened its electronic trading platform. In 1992 the Chicago Mercantile Exchange (CME), the largest futures trading exchange, became the first major American open outcry exchange to launch an electronic platform. This was followed shortly by the Chicago Board of Trade (CBOT).31 Throughout the 90s, pit trading went out of fashion and the electronic OTC style took favor. It was not until 2006, however, that the New York Stock Exchange went electric. The NYSE continues to have a limited open outcry system as 18 percent of NYSE trades are still operated on the floor.32

Converting the exchanges to become electronic has had clear benefits in making the markets more efficient and global. Electronic trading floors have opened the markets to anyone with an internet connection. Consequently, many automated trading systems have been developed that tend to trade at a higher frequency in response to market movements.33 In 1980, before electronic markets came around the NYSE yearly volume was in the 11.5 billion shares and by the 2000 that number had grown to 262.4 billion shares.34 One benefit of this is that demand for brokers with lower fees as was seen with a reduction in commission per share traded from $0.25 to below $0.05 during this time.35 This in turn benefitted individual investors who were able to turn their equities more liquid and contribute to a more efficient market. The competition to reduce transaction fees has ultimately resulted in a fee-less brokerage.36 Launched in 2013, Robinhood became an international success overnight by offering a free service with the plan of making money off margin trading.37 Within 3 years, Robinhood reached a customer base of over a million people and has received $176 million in venture capital funding.38 The mobile accessibility and free access has kept the millennial generation investing in equities in spite of lower incomes than other generations at the same age.39

Another large development that increased global market knowledge as a result of the exchanges going electronic was the invention of the Bloomberg Terminal. Invented in 1982 as a way for investors to see market news and the latest price quotes.40 At the time it took several minutes for the terminal to quote prices, and its network of news was limited to a few sources. However, as its number of subscribers grew and the technology to process data and feed it to clients improved, Bloomberg went from a niche startup to one of the largest FinTech companies with 5000 engineers.41 Today, Bloomberg receives $9 billion in annual revenue from their terminals and its features include up to the second price quotes with data visualization, news updates from all of the major financial outlets, a messaging service between banks, and a brokerage service.42 With the Bloomberg Terminals and cheaper software that mimics it, investors were able to access reliable and visualized data that allows them to make swift and informed decisions.43 This contributes to a more efficient market as the prices of assets more clearly reflect all the available information to investors.44

Part 2: What is Artificial Intelligence

*“Maybe the only significant difference between a really smart simulation and a human being was the noise they made when you punched them.”--Terry Pratchett*

**Introduction:**

Artificial intelligence is one of the buzzwords that has loomed over society for the past 50 plus years. As computers increased their capabilities, it has been a consistent fear that human labor and thought will be overcome by the cold-hearted and restless beings that are machines.

This section will explain what exactly Artificial Intelligence (AI) is, and the 70 year evolution of AI from a theoretical concept to a legitimate sub-industry that receives tens of billions of dollars in funding every year.

**What is Artificial Intelligence?**:

Artificial Intelligence is the study of intelligent agents that perceive their environment and act upon them.1(McCarthy) There are many different criteria for what constitutes Artificial Intelligence, however, they are mainly split up by being able to acting or thinking and whether the ideal performance is that of a human or an entirely rational being.2

To be considered able to act like a human is the most traditional method of measuring Artificial Intelligence. The measurement of acting humanely is performed by the Turing Test whose namesake is based on its designer Alan Turing. In the Turing Test, a computer can be considered to be artificial intelligence if a human interrogator cannot tell whether or not the written responses it is getting is from a person or a computer.3(Turing) In order to have these traits a computer must have four specific abilities. The first is natural language processing or the ability to communicate successfully in English. The second is knowledge representation, or the ability to keep what it learns in some form of memory. The penultimate ability is to use automated reasoning which us using memory to answer questions and draw new conclusions. The final skill is machine learning which is adapting to new circumstances, and detect and extrapolate patterns.4(Minsky)

Thinking humanly is less often used method of benchmarking Artificial Intelligence and there is no formal test that a computer must pass in order to be considered as “thinking humanly”. However, computers that are made in order to think similarly to humans requires knowledge of the human mind. One way that artificial intelligence has been set up to think humanly is through neural networks. Artificial neural networks is a set of machine learning where network nodes work together in clusters to solve problems using shared memory, much similar to how the human neural network works.5(Hopfield) The development of neural networking is growing rapidly in the AI field as search engines require them in their search algorithms to bring the most relevant information to the user.6(Milosevic)

Thinking rationally is a criteria that is difficult to define as it requires the computer to be able to perform the “correct” type of thinking. Belief in “rational thought” began its history with Aristotle whose syllogisms began the study of logical thinking where if A=B and B=C, then A=C.7 This logical type of thinking has been the backbone of computer programming, however, it has not been easy to make artificial intelligence to think in this way, especially when knowledge is not certain. The biggest obstacle for computers to think rationally is optimizing the data it is given. Some of the most powerful computers have problems making rational decisions based on only a few hundred variables.

Acting rationally, the final qualification some define as Artificial Intelligence revolves around rational agents that act to achieve an optimal outcome.8(Russell) In order to be considered a rational agent, one has to reason logically in order to decide on an action that will achieve the task at hand.9(Russell) However, sometimes rational outcome is not possible, so the agent must decide what action, if any, will result in the best possible outcome. The skills necessary to pass the Turing Test also apply to acting rationally, however, the rational agent method is slightly improved in that it is more responsive to scientific development. As artificial intelligence becomes a larger part of industry, a greater number of people use rational action as their barometer of AI.10(Russell)

**A History of Artificial Intelligence**

The first universally accepted introductory work of AI was performed in 1943 by Warren McCulloch and Walter Pitts.11 McCulloch and Pitts proposed a model of neurons that would be characterized as on or off in response to stimulation from surrounding neurons. This proposition was based on the basic physiology of the human brain, propositional logic, and Turing’s theory of computation. McCulloch and Pitts believed that the network of neurons could learn by updating the strength in connection between neurons.12(McCulloch & Pitts)

While McCulloch and Pitts may have been the first ones to theorize artificial intelligence, it was John McCarthy of Princeton would lead the first implementation of AI. In the Summer of 1956, McCarthy brought together some of the top minds in the study of computer science and intelligence to Dartmouth to “find out how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves”. At this retreat, Allen Newell and Herbert Simon of Carnegie Mellon developed the Logic Theorist program that is “capable of thinking non-numerically, and thereby solves the venerable mind-body problem.”13(Russell) In additional to Newell and Simon, researchers developed an AI programs where a computer could play a human in checkers. This was the first instance in a long series of programs where the mind of a computer could compete against a human in a board game.14(McCarthy)

Shortly after their Logic Theorist, Newell and Simon came out with another hit, the “General Problem Solver” (GPS).15(Newell & Simon) The GPS took humanlike approaches to solving puzzles in that it made subgoals and then aggregated the subgoals into completing the whole task. Not long after the camp at Dartmouth, John McCarthy moved to MIT where he developed the Lisp language which is the basis for most modern AI programming languages. McCarthy was joined by another founder of AI, Marvin Minsky, in 1958. Together they developed the Advice Taker, the first hypothetical AI system that is still used as a model today.16(McCarthy & Minsky)

After the initial breakthroughs in Artificial Intelligence, the so-called “founding fathers”–McCarthy, Simon, Minsky, and Newell became overconfident in their predictions. In 1957 Simon was quoted as saying the ability of machines to learn and create would surpass humans in the visible future. Furthermore, he believed that by 1967 a computer would be a world chess champion.17 These beliefs were given a hard dose of reality as the early AI programs were simple and required few neuron connections to carry out the task. One of the noted difficulties occurred with language translation where computer interpretation of Russian to English was an utter disaster.18(Pierce) Furthermore, early belief was that solely faster hardware would improve the scalability of Artificial Intelligence programs. This proved not to be the case as it turned out there was massive diseconomies to scale required in machine evolution. As a result, complex problems such as beating chess masters became impossible to solve given the current state of AI solutions and computer hardware.19(Russell)

The first breakthrough to tackle the issue of scalability came in 1969 with the development of the dendral program. Previously, AI problem solving had been performed with so-called “weak methods” which solely connected small steps to a complete solution. As they had learned the hard way, this did not work for specific complex issues such as playing chess. The dendral program was the first implementation of domain-specific knowledge which allowed for better handling of cases in an expertise.20(Lindsay) The dendral program was developed at a Stanford lab by a team of computer scientists and geneticists when trying to find a way to guess a molecular structure given data from a mass spectrometer. Originally, the program made all possible structures with the formula, and then guessed the mass which proved to be extremely inefficient. To solve the issue, consulted chemists gave the research team ways to seek known patterns in the molecules. The new program using the consulted methods turned out to be a tremendous success and a major breakthrough in domain-specific AI. Later the same team of researchers that developed the Dendral program also developed the Mycin program that could diagnose blood infections as well as blood experts. The success of the Dendral system did not stay at Stanford, however. Yale linguist Roger Schank developed a program to understand natural language and the issues of having the knowledge required for understanding language.21(Schank)

By the time the 80s rolled around, commercial institutions began implementing artificial intelligence. The first system R1 was developed at Digital Equipment Corporation and arranged orders for computer systems. R1 was such a tremendous success that by 1988 they had 40 R1-esque systems deployed saving the company hundreds of millions of dollars a year.22(Russell) The success of DEC led an increase in AI research development from a few million dollars to over one billion dollars in less than a decade. Systems that were developed included vision systems to visualize data, and robots to act upon the sight. Once again the lofty goals of AI were too much for researchers to handle, and commercial AI went into a recession that lasted until the 21st century.23(Yang)

Despite the slump in AI following the 80s, people began to see a small resurgence in the late 1990s. One of these examples was with the acceptance of the intelligent agent. As discussed in the previous section, an intelligent agent acts based on what will maximize its success for a given goal. An intelligent agent is an economical way of thinking that deals with solving subproblems.24(Russell) Intelligent agents appeared with the explosion in internet popularity, specifically in reference to bots and search engines. Search engines in particular are dependent on intelligent agents as the results of a query are specifically tailored to a number of variables of the user including location, age, gender, and personal preferences. Intelligent agents have found most of their success in internet applications, however, as industry machinery has struggled with it due to sensory perception of machinery faltering.25(Bhute) In addition to the internet breakthroughs of the 90s, Deep Blue, a computer developed by IBM defeated world chess champion Garry Kasparov in a six match competition.26

Since the turn of the 21st century, AI has largely been about handling large datasets for help with analytics. This is largely due to the merging of AI with standard computer science algorithms. In modern computer science, people are becoming less worried about algorithms to apply for organizing data and more worried about gathering data so that AI itself can sort it out. One of the methods that was used to teach a computer to generate coherent and relatable sentences came from something called “bootstrapping”. Bootstrapping is a method that uses random sampling with replacements and constantly gets feedback in order to accurately represent the data.27(Russell) As the amount of text grows, the computer begins to formulate its own sentences better and better until it is fluent in language. Additionally, solutions to knowledge bottleneck–knowing what a system needs for a solution–have been introduced with the invention of these bootstrapping-type learning methods. These breakthroughs lead many to believe that we are on the verge of an AI revolution.

Part 3: The AI Invasion in Finance

*“We are now a technology company.”*

*--Lloyd Blankfein, CEO Goldman Sachs*

Similar to any other industry, finance has been affected by the development of artificial intelligence. This section will discuss the different types that currently in use or production by financial institutions as well their success and future. Finally, this section will provide insight on what the future role of a banker will look like.

**Robo-advisors**

Perhaps the most widespread use of AI in finance has come with the development of robo-advisors. Robo-advisors, which typically use a more passive asset management system, have shaken up the mutual fund industry immensely in the past few years. Although the industry started during the 2008 financial crisis, it has grown insurmountably with an expected $2 trillion in assets managed by robo-advisors by 2020. This part will provide an overview of the history to this point of robo-advisors, an explanation on their inner-workings and common strategies, and what the robo-advisor business will look like going forward.

The history of robo-advisors is not a lengthy one. The first robo-advisors were founded in 2008 amidst a global financial meltdown as a cheaper alternative for investors to receive advice on their holdings.1 Prior to 2008, many human financial advisors used software that gave advice on what to buy and sell based on preset algorithms that examined market movements. The first robo-advisors were essentially the same as the software used by financial advisors, except they eliminated the middleman and could be used by the consumers themselves.2 Silicon Valley took notice of the potential profit of automated advising and within no time, systems such as Betterment and kaChing were developed.3 Betterment in particular caught on with investors and since it launched in 2010 it has gone from a startup to an investment company with $10 billion in assets under management (AUM).4 It did not take more than a few years for the large mutual funds to catch on with the competition. In 2015 both Charles Schwab and Vanguard launched their robo-advisors for clients with at least $50,000 and $5,000 in capital, respectively.5 The programs became an instant success with AUM being $65 billion and $16 billion at present time.6

One of the unique features of robo-advisors is that they all adhere to a passive indexing strategy, or investing in a market-weighted index or portfolio.7(Lam) Passive indexing has been shown as a beneficial strategy due to higher diversification, and low management and transaction fees.8(Bogle) Furthermore, empirical evidence has shown that a mutual fund’s ability to pick stocks stocks that outperform market averages is largely a fallacy. This has been illustrated thoroughly in three major works in the past 50 years. The first was by Princeton Economist Burton Malkiel in his 1973 book *A Random Walk Down Wall Street* where he wrote that a company’s returns versus markets averages tends to follow a random walk and thus past prices do not contain enough information to hypothesize future stock predictions through technical or fundamental analysis.9(Malkiel) This research was updated by Yale’s David Swensen in his 2005 book *Unconventional Success*. By examining the largest active mutual funds, Swensen found that after fees and taxes, the largest funds underperformed market averages 86% to 96% of the time. Furthermore, he discovered that the average gains of a mutual fund that does outperform the market was less than the absolute value of the average losses of a mutual fund that does not outperform the market.10(Swensen) Lastly, in 1975 investment analyst Charles Ellis wrote *Winning the Loser’s Game* which spoke of the effect mutual funds had on the efficient market hypothesis. Ellis wrote that active institutional investors were involved in a prisoner’s dilemma scenario where they each spend so much effort in beating the market that in doing so they create the market they are trying to beat. The more they try to beat the market, the more they rack up in transaction fees which in the long run puts them in an even deeper hole.11(Ellis)

Robo-advisors still follow the same steps in investment as all institutional investors of: asset allocation, implementation, and monitoring and rebalancing. There is, however, differences in how these steps are enacted. In terms of asset allocation, robo-advisors tend to allow its clients to withdraw leaving them with liquid assets such as stocks, bonds, and tax harvesting. After figuring out the asset classes they can invest in, robo-advisors will then estimate make market assumptions about the expected returns and risks of potential asset classes. This is performed with built in algorithms that figure out the efficient frontier of the different assets using Markowitz’ mean-variance analysis. The robo-advisor will measure correlations between the assets as well to minimize systemic risk and make well diversified portfolios. The amount of risk is typically based on the investing needs of the client. For example, if the client is older, they will not need as much risk in their assets and thus will typically be heavily invested in bonds. In terms of implementation, robo-advisors select the assets (specific indices) that meet the criteria of the clients needs.12 In addition to picking assets, newer robo-advisors will also tax-loss harvest. This means that they will sell securities for a loss and use the proceeds to buy correlated assets to substitute.13 This takes advantage of capital losses, and the portfolio return increases with the tax rate arbitrage that is obtained. The final step of robo-advising is monitoring and rebalancing the assets. Passive investing calls for threshold reinvesting as opposed to time reinvesting. This means that once returns are a specific percentage away from the target, the advisor will automatically perform the necessary trades to rebalance the account to the correct mean-variance levels.14(Jaconetti et al)

The main difference between robo-advising and traditional financial advising is that financial advisors are human and thus have biases that are faulty to investing. This can be seen in the different steps of investing listed above. With asset allocation, traditional advisors typically do not use mean-variance analysis or proper portfolio when selecting assets to invest. Additionally, advisors are largely incapable of performing the same level demographic analysis as robo-advisors when considering age, income, wealth status, and often incorrectly take gender into consideration. In terms of implementation, monitoring, and rebalancing, human advisors are subpar at balancing the tradeoff between high performing assets and transaction fees.15(Jaconetti) This balance is not hard to figure out for robo-advisors that focus on selecting ETFs that minimize expense ratios and maximize tax efficiency. In addition to improved investment methodology, robo-advisors also have more clarity when it comes to investment advice. A large part of how human advisors keep clients is by complicating their advice so that it appears that the layman cannot understand. Robo-advisors have nothing to lose by telling the truth, so they explain their exact strategies and asset allocation.16(Mullainathan et al)

In addition to the benefit of better returns from passive management in comparison to active management, there has been empirical evidence of success of robo-advisors reducing fees and inefficiencies in its trading. An in-house study by robo-advising company, Betterment found that their expense ratio was was 0.13%, much lower than the fund industry average of 0.52%.17(Betterment) Furthermore, the transparency of robo-advisors has been shown to be much improved. Another study found that 30% percent of advisors refused to offer their trading strategy before their clients transferred funds.18(Mullainathan et al) Furthermore, despite robo-advisers being criticized for lacking a personal touch, they have been shown to be better at personalizing portfolios to the investor’s needs. A study of Canadian financial firms in 2015 showed that human advisors only covered 12% of the cross-section variance of the demographics while robo-advisors covered 30%19.(Foerster et al)

Robo-advising has theoretical benefits to the markets as well in the same way that automated trading does. Besides increasing the disposable income of its investors through smarter investing and smaller fees, robo-advisors will also increase market efficiency. Similar to automated trading systems, robo-advisors update portfolios on a price basis rather than a time basis. This means that if an ETF underperforms below a certain threshold, the robo-advisor universe would buy more or sell depending on the needs of its investor. This automatic adjusting system that is tailored to each investor is the perfect scenario for an efficient market as it is fluid and consistently fits the investment needs of the populus. Furthermore, since it is meant to benefit individual people instead of a fund, it improves efficiency even more than an a traditional trading system. Increased rebalancing will also improve the diversification of portfolios as the number of eggs in each basket will constantly be transferred to a preferred amount. With diversification comes an improved economy as bubbles are theoretically less likely to develop and if they do then the systemic shock should not be too big. In addition to constant rebalancing, robo-advisors also contribute to market efficiency as they will likely lower the transaction fees on equities. Volume of stock purchases is the main reason why these fees are lowered. This was seen throughout the 80s and 90s when algorithmic trading got more common and the average commission per share on the NYSE was reduced from $0.25 to $0.025 in slightly over two decades.20 Moreover, robo-advisors will eventually make advising to the capital markets accessible to a worldwide audience. While typical financial advisors is only accessible with respect to your geographic location, robo-advisors are available to anyone with an internet access. Although they are currently available to people with roughly $10,000 in available capital, as competition increases that number will continuously decrease.

In the same way the proponents of robo-advising admire the humanless investing, its opponents believe that they are not as humanless as you think. Melanie Fein a former Senior Counsel to the Board of Governors of the Federal Reserve is one of these detractors. One of her criticisms is that advisors are not as tailored to the clients as they are hyped up to be and overly simplistic and general. This can be seen in the questionnaires that robo-advisors have clients fill out which only ask a few questions and the information “can result in no more than superficial asset allocation and investment recommendations.” Other criticism revolves around the fact that the robo-advisors are not as they claim in being a cheaper, no conflict, and selfless system. Although they offer lower transaction fees through ETFs, robo-advisors will routinely collect hidden fees put in their investment products and services. These hidden fees include mutual fund advisory fees, brokerage fees, and have the right to charge or change fees whenever they feel. These hidden fees combined typically make a robo-advisor more costly than most 401(k) plans. Furthermore, robo-advisors appear to have conflicts of interest. Robo-advisors are typically managed by mutual funds that are affiliated with certain brokers, clearing firms and securities, and thus will use their services at the cost of the consumer. Robo-advisors are under no regulation that forces them to act in favor of their clients, and thus are predisposed to selling out their clients for another interest of the fund.21(Fein)

With the growing assets under management by robo-advisors, it is hard to imagine that trend will change in the near future. The sustained success of passive asset management and availability of low transaction fees will hard to ignore, especially for generations that value face-to-face services less than their predecessors.22 As the number of mutual funds and wealth managers that offer robo-advisors grow, the fees of robo-advisors will go down and they will compete to offer the most suited portfolios for their investors. The rise of robo-advisors will not bode well for traditional advisors. These active managers will need to significantly lower their fees to be able to compete. For this reason, funds will further their trend of hiring people well versed in programming and statistics to build and maintain the robo-advisor models. Since robo-advising is largely self-updating, funds will be able to employ fewer people than they currently do, which in theory should make a combination of lower fees and more profitable funds.

**Market Analysis and Risk Management**

The implementation of AI in finance allows for a dynamic market analysis system that will not rely on constant work by the high paid quants on Wall Street. With the increasing availability of data, improved systems continue to be able to mine the data, interpret it, and give it to humans to be able the most informed decisions. This section will explain the process of Big Data market analysis by private equity firms such as BlackRock, how more information will help the economy at large, and the dangers that may result from AI market analysis. Please note that since these market analysis systems are still in development and are largely proprietary, scholarly literature is sparse. Therefore, much of the discussion will be from the point of Big Data application as a whole.

When it comes to AI assistance in financial modeling, BlackRock’s Aladdin is the name that stands above all. In 2000 BlackRock created the risk management division BlackRock Solutions and with it the Aladdin (Asset, Liability, and Debt and Derivative Investment Network) System, a software platform that would analyze risk and manage the company’s assets. Aladdin is run at a center with over 6,000 computers in Wenatchee, Washington, although its power stretches the world. Since then Aladdin has grown to handle BlackRock’s $6.0 trillion assets and $15 trillion in total. Over 170 pension funds, banks, endowments and insurance companies entrust Aladdin to handle their assets. In total Aladdin manages 7% of the world’s financial assets, and that number is growing steadily.23 Aladdin’s technology has also evolved over the years. Over the years it has evolved from an asset manager where quantitative analysts would implement traditional mean-variance tools to select the asset classes, and has since grown to run most aspects of BlackRock. Jody Kochansky, the head of the Aladdin Product Group explained that now “AI is woven into the fabric of nearly everything we do: from improving efficiencies in our operational processes, to helping our clients invest in the marketplace, to better understanding our clients and their investment preferences.”24 BlackRock calls Aladdin its “central nervous system - uniting all the information, people and technology needed to manage money in real time.”25 Additionally, has made a name for itself by taking into consideration all news for its models. Then it uses this data using historically fitted algorithms to perform Monte Carlo simulations to paint a picture of the most likely scenarios.26 Aladdin is the industry leader due to its scalability, learned knowledge, and extensive modeling techniques.

In addition to Aladdin, some other big finance players have hopped onto the AI market analysis bandwagon. UBS and Deutsche have used the Sqreem engine for a four years.27 Founded in Singapore 2010, Sqreem prides itself in helping its clients identify the “unknown unknowns”.28 The system “analyzes people’s digital footprints to predict what which products and services they most likely want”.29 Goldman Sachs is not falling behind on this front either. It recently has begun using Kensho, a machine learning system started in 2013 that is built to act like a next level Google.30 Kensho uses its own global event database and processes the user’s inquires to produce data visualizations to guide the user’s decision. So, when someone on the Goldman Sachs modeling team wants to know what will happen to oil stocks if a hurricane were to hit southern Texas, Kensho would be able to provide a model.31

Despite providing top-notch data to its clients, these AI market models have their downside which is a lack of diversification. Currently, Aladdin has $15 trillion assets under management, more than every nation besides the United States, China, and Japan.32 As Aladdin’s AUM continues to grow, it just shows that investors are thinking in a similar mindset. In the event that a unique event were to happen in the market, it is possible that it could crash the so called immune system of Aladdin and thus the economy. Due to the intelligence of Aladdin this may not seem possible, however, the 2010 “Flash Crash”–where a few spoof trades set off many trading algorithms and sunk the Dow Jones 10% in 36 minutes–should be a warning sign to investors that correlated investments could hurt a market.33(Kirilenko et al.) Given that Aladdin is beginning to automatically invest in addition to giving advice, it should come as a greater alarm to investors. While the cause for concern is legitimate, competing market analysis tools such as Kensho should create some diversity in tastes in the near future.

**Underwriting**

The most recent AI undertaking of banks has been underwriting loans. While the use of quantitative methods of measuring risk for FICO credit ratings has existed since the 50s34 and computer models to assess this risk has been around since the 80s, the new development of applying for loans and receiving feedback with minimal human interaction is brand new, This section will explain the new technology that has been put into place to make this happen, and the challenges that AI underwriting faces. However, given how new of a development this feature is and their competitive nature, studies showing their success have not come out.

ZestFinance and Upstart are the two main startups that have gotten the ball rolling on AI underwriting. Founded in 2009 by former Google CIO Douglas Merrill, ZestFinance was intended to help fix some the issues of poorly informed lending from the FICO system where many institutions only require a few facts before offering the loan. ZestFinance planned to do away with the traditional credit score system and instead rely on their machine learning system to use as many data points as they can to analyze the risk of consumer loans. ZestFinance has received over $250 million in funding and is especially useful in emerging markets such as China and India and for financial institutions targeting younger Americans where little credit information exists.35,36 While ZestFinance has been used for consumer lending, Upstart is used for personal lending from between $1000 to $50,000. Like ZestFinance, Upstart has Google roots where its founder Dave Girouard was a former VP.37 Upstart offers 3 year and 5 year loans, and has also done away with the FICO credit system. Instead it is designed for young adults, measuring academic variables–GPA, standardized test scores–and work history to build a model measuring financial capacity and default risk. In less than five years, Upstart has received $86 million in funding, mainly from Japanese e-Commerce company Rakuten, and investment analyst company Third Point.38 Goldman Sachs is the first major financial institution to hop on small automated personal loans with Marcus. Launched in October 2016, Marcus had already lent $2 billion soon after its first anniversary.39 Marcus is operated entirely online and requires only tax documents, pay stubs, bank statements, and photo ID. After processing this information, Marcus will use its built in modeling techniques to determine if you qualify for the loan asked for and at was APR you could receive the loan. The loan is then sent out and there are no fees that come with it.40

Despite the lack of studies on the new development of AI underwriting, there are certainly speculated issues. One of these is the lack of financial information necessary for loans with ZestFinance and Upstart. While more modeling that produces statistically similar risk ratings is nice in particular for foreign and younger people asking for loans, straying away from the core of what matters most could be an issue. While external factors such as GPA and marital status have been used to assess insurance underwriting for years, risk of loans are entirely built on whether someone has the capability and history of paying people back, and the traditional FICO system does that. Furthermore, opening up to other variables opens up to capabilities of prejudice with respect to race or gender. While federal law prevents such lending to happen, there has been recent history of lending institutions using demographic information in the wrong way, namely Bank of America’s $335 million lawsuit for predatory lending against African Americans.41 Since it took years to discover Bank of America’s wrongs, it would be even more difficult to find it in AI lenders where code is patented and hidden from the public eye.

In spite of the dangers that exist from AI lending, the online platform allows people to receive small loans in the convenience of their homes without the risk of hard-selling lending agents and mountains of paperwork. Moreover, as more data points are analyzed for credit risk, lending will be more available for people without much credit data such as foreigners and young adults. While studies have yet to come out about the subject and major issues have yet to happen, the speed and Big Data factor should make for a safer and more efficient market

**Future Role of the Finance Employee**

Thus far we have seen the changing worldwide industry with the introduction of AI and the different products financial institutions can offer as a result of it. However, we have not looked at the structural changes of the banks and the people they employ. The role of the future finance worker will resemble little of its qualitative past. Although the age old banking institutions will remain on top with the same purpose to act as a financial intermediary for their clients, their way of carrying out business will go from one that relied on personal connections to a more quantitative one that tries to optimize the amount of money in their client’s pockets. This section will outline the reasons why financial institutions are changing rapidly, explain what the role of the banker of the future looks like, and the challenges that will result from these changes.

There are several reasons why financial institutions are switching to a more tech and Artificial Intelligence focus. The first of which is that technology makes them money. If they did not have to use technology to stay afloat with competition, they never would since research and development is expensive and one does not need to fix what is broken. This was already seen for nearly 1000 years in banking when the only technology required in finance was paper. However, in the 20s financial institutions began seeing how much money could be made from money technology with being able to telephone in your stock orders to brokers. The development of communication technology in general has been huge for finance as we saw with electronic trading platforms. After World War II, the mathematicians such as Harry Markowitz showed how being able to handling market data to perform mean-variance analysis could benefit investors. This brought computers and rocket scientists from around the world to Wall Street who implemented automated trading systems. Eventually these top minds moved to creating pricing models for other asset classes such as bonds, options, and mortgage backed securities. Derivative modeling became a lucrative undertaking for sell-side and buy-side institutions. Banks were able to play the “house-always-wins” approach by offering swaths of collateralized debt and credit default swaps which guaranteed income as long as credit did not plummet. With quantitative investing, hedge funds were able to employ fewer people, and those they did employ could focus full time on “discovering” market inefficiencies. Goldman Sachs for example was able to bring their 600 traders down to 200 engineers within a decade.42 After the market crashed in 2008 and the glory days of free-wheeling deals came to an end on Wall Street, banks and funds had to find ways to cut the fat, and offer loans or invest in smarter ways that reduced risk of default while increasing returns. All of this has lead to financial institutions investing in technology where human labor can be reduced over time while increasing the efficiency. Technology that can give personalized investment advice better than any human, that can offer loans based on all available verifiable financial data of a person, and that piece together all financial news in a split second to provide predictions for future returns. Artificial Intelligence is the only technology that can do this.

The second most important reason that banks are integrating more technology is because can only use the technology that is available to them. While brokers would have loved to have had widespread use of telephones in the 1880s and 1890s to increase orders, few people had phones to make it work. Similarly, it took a World War for data handling computers to be invented, and the internet for trades to be able to execute online. The same goes for use of Artificial Intelligence. The discipline did not have major commercial breakthroughs until the 2000s and has required supercomputers and a large network of distributed computing to even be able to handle the vast amount of financial data, and then be able to enact upon it. However, since the technology is now available and it applies to the industry, financial institutions are able to pour in money to use it properly.

The third main reason why financial institutions are transforming into technology companies is due to their growing size. The fact is that since after the Great Depression, American industry has been in a golden age of mergers and acquisitions. While the industrial era may have seen monopolies arise, the second half of the 20th century has seen conglomerates spread their tentacles in many different industries and sub-industries.43 The financial industry is no different. Since 1984, the number of commercial banks in the United States has gone from 14,400 down to under 5000.44 The largest banks have grown drastically in this time period as well. In 2000, JP Morgan Chase had total assets around $400 billion and by 2011 that number skyrocketed to $2.25 trillion.45 As big names get bigger, they are able to have large scale side projects that could potentially result in significant returns. This is the exact case with Artificial Intelligence. For a bank to be able to have a working AI system they would need the capability to handle large amounts of data and a large user base for the system to have successful economies of scale. While increasing bank and private equity size has shown the danger of too big fail, it has also brought more efficient conducting of financial business. For example, something with the capabilities of BlackRock’s Aladdin or Goldman’s Kensho would not be possible without the capital and outreach of their respective companies. As the size of these institutions continues to grow, the increase in research and development of technology will increase and most likely crowd out their human labor spending.

With the increased focus on technology, the role of the financial employee is set to change drastically. In 2016 alone the financial services spent $480 billion, a 5% increase from the year before.46 While that does not seem like much, a large portion came from the top players. Goldman Sachs spent $3.2 billion on technology alone in 2015, worth nearly 10% of their revenue.47 JP Morgan was similar, spending $9.5 billion, which was 20% of their yearly revenue.48 Artificial Intelligence takes up only a small portion of this chunk, however. In 2017 the financial services industry spent $4 billion on Artificial Intelligence research and development, however, that number is roughly 14% of AI R&D across all industries.49(McKinsey) The CEOs of these two behemoths have been outspoken in the evolution of their companies. Jamie Dimon of JP Morgan has called technology the “greatest thing for mankind”.50 Likewise, Lloyd Blankfein is proud of his company’s dedication for technology often pointing out that Goldman Sachs employs more engineers than Facebook.51 Of the 33,000 Goldman employees, 9,000 are programmers or engineers, and have even opened up an office in Salt Lake City that largely houses these tech workers. Harvey Schwartz, the COO claims that the 9,000 “is likely to keep growing”.52 The result of the increase in tech workers means fewer jobs for everyone else, however. In June 2017, a McKinsey report stated that within the near future 30% of the current positions at banks will be automated.53(McKinsey) With the increasing global outreach of these banks, the employees will not look the Ivy League frat boy part of old either. In 2016, 38.7% of United States based Goldman Sachs employees were Asian, Latino or black.54 Furthermore, the new tech emphasis will new finance worker will closer resemble a Silicon Valley startup star. The employee base will favor a younger audience as Goldman Sachs reported that between 50 to 60% of their employees are 30 or younger.55

While not previously mentioned in this paper, it is important to add that in addition to increased knowledge of modeling and implementing self-learning systems, understanding blockchain currencies has begun to become a crucial part of banking. With the recent frenzy of surges in the cryptocurrencies BitCoin, Ethereum, and Litecoin, banking CEOs have finally broken their silence on their thoughts on the matter. In November 2017, Blankfein stated “I’ve learned over the years that there’s a lot of things that workout pretty well that I don’t love.”56 This came into fruition the following months when he stated that Goldman Sachs would begin clearing BitCoin futures for its clients when CBOE Global Markets begin trading BitCoin futures on December 10.57 While not committing to anything, Dimon has stated that JPMorgan is now open to cryptocurrency and that they will be looking into joining Goldman in CBOE.58 This is huge news and shows the drastic change in opinion on cryptocurrency as six weeks earlier Dimon stated that Bitcoin was a “fraud” and that if any JPMorgan were to trade BitCoin he would “fire them in a second.”59 Bank of America has also looked to enter the cryptocurrency market, by obtaining a patent for a crypto exchange system.60 However, despite three of the largest names coming around to legitimize cryptocurrency, other banking leaders are skeptical at best. CitiBank has repeatedly stated that they will hold-off for the time being, and Deutsche Bank is waiting for regulation to get involved.61,62 Tidjane Thiam of Credit Suisse is not planning on jumping into the fire anytime soon saying that BitCoin was “the very definition of a bubble” and “from what we can identify, the only reason today to buy or sell bitcoin is to make money, which is the very definition of speculation and the very definition of a bubble” and given history “speculation has rarely led to a happy end”.63 However, with a market cap of nearly $300 billion, BitCoin will be impossible for these financial institutions to ignore forever.

The issues with many banks going tech is that it is bound to create even less competition industry. With clients wanting the greatest and most efficient tools to handle their money, the growth in capital of the large banks will be expedited growing the gap even further. This will allow larger banks to offer better deals in return and continue to buy out the smaller banks. As a result, we have less diversification in global assets under management. As we have already seen with the 2008 recession, a near oligopoly in the banking industry lead to overconfidence which lead to greed which led to the the financial industry getting slaughtered. However, given the self-adapting and diverse nature of Artificial Intelligence, this is less likely to happen and these benefits of may outweigh the lack choices for investors.

**IV. Conclusion**

The previous 100 years of banking resulted in more changes than the previous 1000 years, and the next 10-20 years will cause an evolution greater than the past 100. Since the integration of computers into finance the industry has seen a technology revolution. It has learned the importance of global outreach to broaden the consumer base, the vitality of data analysis to make the most efficient use of assets, and the dangers with limiting the scope of the models.

With the lingering effects of the 2008 recession, banks have had to decide how to fulfill these principles while minimizing costs and this has begun with the development of Artificial Intelligence (AI) in finance. AI has so far come in the way of robo-advisors, market analysts, and loan underwriters. Thus far it has increased the speed of financial transactions, provided the availability of an analyst to anyone with an internet connection, and personalized asset allocation that has fattened the wallet of its clients while increased diversification of assets.

Furthermore, the development of AI has meant that inner-structure of financial institutions will be changed drastically. Already we have seen the largest banks invest billions of dollars in technology and personnel, and market reports suggest that these investments will eventually automate a large portion of workforce in these banks.

The infancy of AI in finance has brought challenges both actual and speculative. One of the issues is that because it has not been developed enough, some of its services do not actually help the client. This has been shown with robo-advisors who do not take enough demographic information in their surveys to properly personalize an investor’s portfolio. Additionally sometimes its apparent monopoly causes concern for economic distress. BlackRock’s market analysis tool–Aladdin–is speculated to be too large in its assets under management to be safe for the economy as a whole as similar analysis leads to similar investments which means a lack of diversification.

With the rapid technological changes that the financial industry has undergone in the past 10 years one can only speculate jobs in finance will be automated next. Maybe mergers and acquisitions will be performed by a computer. Possibly IPOs could be determined up by robo-investors in a blink of an eye. Or perhaps we undergo another AI winter that never ends and we revert back to the traditional banking system. It appears that John Allen Paulos’ famed “uncertainty is the only certainty there is” is the only certain way to sum up the financial industry’s current situation.

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