CBTT Research Review Seminar 2023

Trinidad And Tobago Unit Trust Corporation

August 2023

TOPIC: THE TRANSFORMATION OF INVESTMENT MANAGEMENT USING ARTIFICIAL INTELLIGENCE IN THE ENGLISH-SPEAKING CARIBBEAN

Authors: Andrew Maharaj, Ashwini Singh, Cedric Thompson, Omar Burch-Smith, Ravi Kurjah
Sharlene Dabideen

Affiliated Institution: TRINIDAD & TOBAGO UNIT TRUST CORPORATION

TABLE OF CONTENTS

1. INTRODUCTION

The world today can be described as a summation of revolutions both technological and industrial, that have shaped the way we communicate, work, travel and live in general.

A technological revolution can be defined as a period in which one or more technologies are replaced by newer technologies in a short period of time. It is usually characterized by the acceleration of technological innovation, and the rapid application and spread of these technologies that bring about drastic changes in society. This innovation typically sees increases in productivity and efficiency across all sectors through the introduction of new devices and systems.

Some argue that the best-known examples of technological revolutions were the Neolithic Revolution that resulted in the birth of agriculture, the Industrial Revolution of the 19th century, the technical revolution which commenced in the second half of the 20th century, and the Digital Revolution. Many others simply categorize them as the First, Second, Third, and now Fourth Revolutions, respectively.

The First Industrial Revolution was triggered by the steam engine in the 18th century and led to the mechanization of industries. This mechanization led a transition away from agriculture toward industry as the backbone of the societal economy (iED, 2019).

The Second Industrial Revolution commenced in the late 19th century with technological advancements in industries that helped the emergence of new sources of energy including electricity, gas, and oil which also resulted in the creation of the internal combustion engine.

The Second Industrial Revolution also brought about increase in the demand for steel, innovations in transport, with the inventions of the automobile and airplane at the beginning of the 20th century, and new methods of communication including the telegraph and the telephone.

The Third Industrial Revolution, commonly known as the Digital Revolution, commenced in the 1950s and brought forth the rise of electronics, telecommunications, the introduction of semiconductors, mainframe computing, personal computing, and the internet.

The Fourth Industrial Revolution (4IR) or Industry 4.0 is a term that was coined in 2016 by Klaus Schwab, Founder and Executive Chairman of the World Economic Forum

(Lavopa & Delera, 2021). It is characterized by the convergence and complementarity of emerging technology domains including nanotechnology, biotechnology, new materials, and advanced digital production (ADP) technologies.

According to McGinnis (2023), the Fourth Industrial Revolution is a way of describing the blurring of boundaries between the physical, digital, and biological worlds. It is a fusion of advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), Web3, blockchain, 3D printing, genetic engineering, quantum computing, and other technologies.

Many are of the belief that the central underpinning of Industry 4.0 will be the evolution of AI and its impact.

While some argue that current technological evolutions and advancements are not consequential enough to constitute a fourth technological revolution, the impact that AI has already had on the world, and how it will potentially impact industry, commerce, finance, education, communication, and every other facet of human development in the future cannot be ignored.

1.1 What is Artificial Intelligence (AI)?

John McCarthy in 2004 described Artificial Intelligence (AI) as the science and engineering of making intelligent machines, especially intelligent computer programs. It can be more broadly described as the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. AI makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.

Since the 1950s, scientists have argued over what constitutes “thinking” and “intelligence”, and what is “fully autonomous” when it comes to hardware and software (West, 2018). Early AI research in the 1950s explored topics like problem solving and symbolic methods, which paved the way for the automation and formal reasoning that exist in computers today, including support systems and smart search systems, that can be designed to complement and augment human abilities (SAS, 2023).

A machine’s AI capabilities are developed through a process known as “machine learning” which Oracle describes as a subset of artificial intelligence that focuses on building systems that learn or improve performance based on the data they consume.

Machine learning algorithms are developed from data collected from humans while going about their daily lives including their use of social media and online shopping. A subset of machine learning is deep learning where neural networks, algorithms modeled to work like the human brain, learn from large amounts of data.

Artificial intelligence can be grouped into two main categories or stages, Weak AI, and Strong AI.

Weak AI, also known as Narrow AI, is trained to focus on specific tasks and cannot perform beyond its limitations. It targets a single subset of cognitive abilities and advances in that spectrum. Weak or Narrow AI drives most of the advancements in AI that surround us today in Apple's Siri, Amazon's Alexa, Google Translate, image recognition software, IBM's Watson, and autonomous vehicles.

Strong AI consists of Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI). AGI is a theoretical form of AI where a machine would have an intelligence equal to humans including a self-aware consciousness that can solve problems, learn, and plan for the future. ASI would likely surpass the intelligence and ability of the human brain.

Both forms of Strong AI are theoretical at present with no practical examples in use today, but Edgar Cabañas in his 2023 article for IDB Invest posited "that the confluence of unlimited data processing and storage capacity, terrestrial supercomputers, and Web 3.0 have paved the way for the massive irruption of AGI". He further theorizes that the exponential learning speed of current AI models has increased by a factor of one hundred million in the last ten years, and AGIs are being fed with all the data available on the internet.

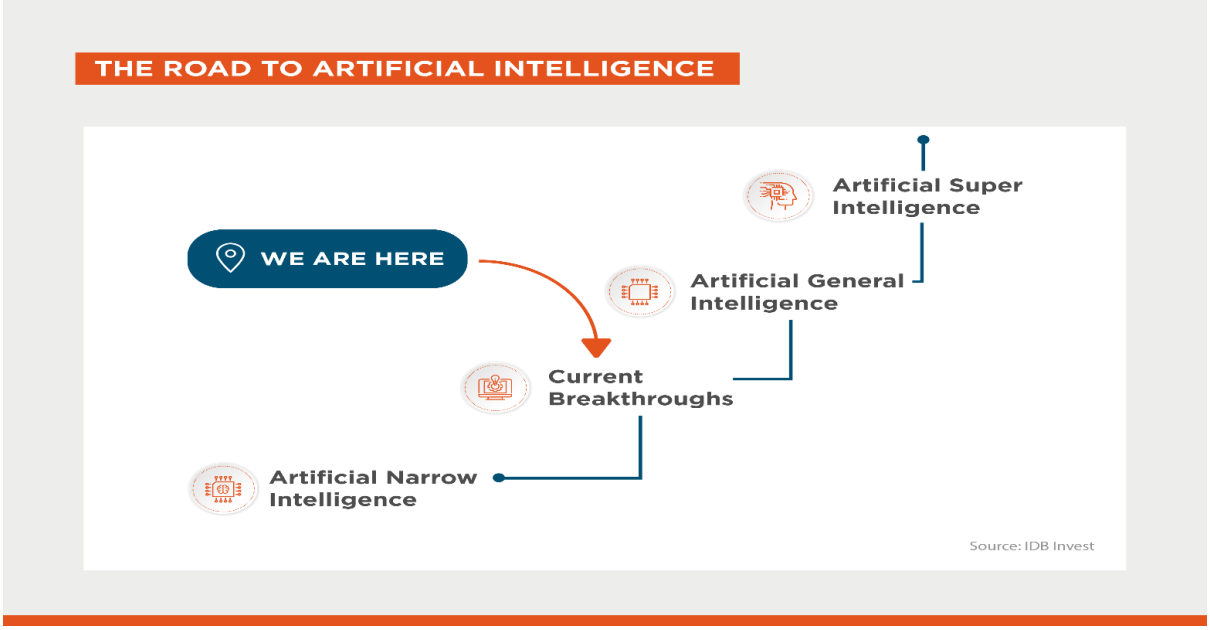


Figure 1 – The Road to Artificial Intelligence (IDB Invest, 2023)

2. A BRIEF HISTORY OF AI

Artificial Intelligence (AI) is a field of science and engineering that focuses on creating intelligent machines, specifically intelligent computer programs. Its main objective is to replicate and comprehend human intelligence using computers. This definition was put forth by John McCarthy, a highly influential American computer scientist in the AI domain (jmc.stanford.edu, 2007).

In 1950, Alan Turing, widely regarded as the father of modern computer science, proposed a method for evaluating machine intelligence. In his ground-breaking work titled "Computing Machinery and Intelligence," Turing transformed the question "Can a machine think?" into whether a machine could exhibit human-like intelligence through its behaviour and simulate the ability to think.

To assess machine intelligence, Turing introduced the imitation game, later known as the Turing Test. This test aimed to determine a machine's capability to engage in text-based conversations in a manner that is indistinguishable from a human. If a machine could successfully imitate human behaviour, it was considered intelligent according to the original formulation of the Turing Test.

AI enables machines to learn from experience, adapt to new inputs, and perform tasks that resemble human capabilities. Many modern AI applications, such as chess-playing computers and self-driving cars, heavily rely on deep learning and natural language

processing (NLP) (IBM,2004). These technologies empower computers to be trained for specific tasks by processing vast amounts of data and identifying patterns within it.

Nevertheless, the development of AI has not been without challenges. While it was initially an exciting and imaginative concept in 1956, AI research encountered setbacks in the 1970s when funding was reduced following critical reports that highlighted the lack of progress. During that time, attempts were made to replicate the human brain through "neural networks," but they were eventually abandoned due to limited computational power and the absence of large datasets.

The most advanced AI programs of that era could only handle simplistic problems and were considered underwhelming. This disappointment arose from excessively optimistic goals set by AI researchers and naive assumptions about the difficulties they would face. Consequently, the funding cuts did not come as a surprise, as the promised results failed to materialize.

2.1. The First AI Winter

The period between 1974 and 1980 is commonly referred to as the "First AI Winter" (Foote, 2022). During this period, funding for artificial intelligence (AI) research was reduced, leading to a decline in interest. However, AI research experienced a resurgence in the 1980s. The United States and Britain, in response to Japan's ambitious "fifth generation" computer project and their aim to become leaders in computer technology, resumed funding for AI research.

2.2. Expert Systems

A significant development called "Expert Systems" brought an end to the First AI Winter. These systems gained rapid popularity and were widely adopted by large corporations worldwide. Expert Systems focused on utilizing the knowledge of experts to create computer programs. Users could ask questions and receive answers within specific domains of knowledge. The software used logical rules and had a simple design, making it relatively easy to build, modify, and use. Examples of Expert Systems from the early 1980s included bank loan screening programs, as well as applications in the medical and sales fields. These straightforward programs proved to be valuable tools that saved businesses substantial amounts of money.

2.3. The Second AI Winter

However, the AI field faced another setback known as the "Second AI Winter," which lasted from 1987 to 1993. This decline coincided with the perception that early Expert System computers, like XCON, were slow and cumbersome. The rising popularity of user-friendly and affordable desktop computers further contributed to the decline of Expert Systems. These desktop computers offered advantages such as easy updates and the ability to learn, by using machine learning to improve performance and adapt to changing conditions or tasks, making them more valuable and versatile for users, these were capabilities that Expert Systems lacked. Additionally, the Defence Advanced Research Projects Agency (DARPA) redirected its funds to projects with the potential for quicker results, as it concluded that AI would not be the next significant wave of innovation. Consequently, funding for AI research was significantly reduced in the late 1980s, marking the beginning of the so-called “Second AI Winter”.

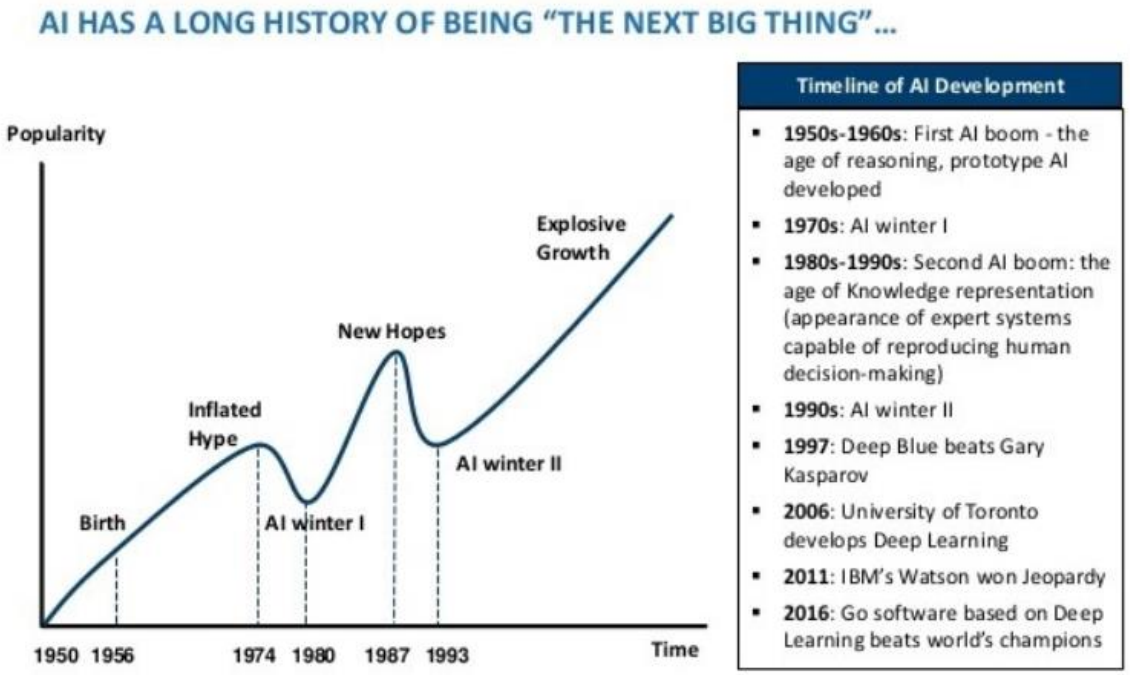


Figure 2 – The Boom and Bust Cycle of AI Research (Lim, 2018)

2.4. Intelligent Agents

In the early 1990s, the field of artificial intelligence (AI) research took a new direction with the emergence of intelligent agents, also known as bots or agents. These agents have found applications in various areas such as news retrieval services, online

shopping, and web browsing. Over time, they have evolved into digital virtual assistants and chatbots, benefiting from the utilization of Big Data programs.

A significant breakthrough in AI occurred in 1997 when S. Hochreiter and Jürgen Schmidhuber developed a neural network model called long-short-term memory (LSTM). This model has proven particularly valuable for tasks involving the retention of memories from numerous small steps, such as speech learning. Around 2007, LSTM surpassed well-established speech recognition programs in terms of performance. In 2015, Google's speech recognition program reported a 49 percent performance improvement by implementing LSTM trained with Connectionist Temporal Classification (CTC). CTC is a network type that addresses sequence-related challenges, including handwriting and speech recognition, which involve timing variations. The use of CTC eliminates the need for a dataset with aligned timing information, simplifying the training process (Bansal, S. 2019).

Furthermore, in 2006, the National Institute of Standards and Technology (NIST) organized the "Face Recognition Grand Challenge" to evaluate popular facial recognition algorithms. The challenge encompassed the analysis of iris images, 3D face scans, and high-resolution facial images. The results demonstrated that some of the more recent algorithms were ten times more accurate than the facial recognition algorithms that were popular in 2002. Additionally, some of these algorithms even surpassed human performance in recognizing faces, including the ability to distinguish between identical twins.

In 2011, Apple's Siri gained widespread popularity and recognition as one of the most successful digital virtual assistants, supporting natural language processing (NLP). Initially, virtual assistants like Siri, Alexa, and Google primarily served as convenient sources of information, providing updates on weather, news, and traffic. However, with advancements in NLP and access to vast amounts of data, these digital virtual assistants have evolved into highly functional customer service tools. They now possess the ability to handle a wide range of tasks and engage users in conversational interactions, offering personalized assistance and enhancing the overall user experience.

2.5. Our Current Status

Currently, AI has become an integral part of our lives, permeating various aspects. For programmers, tools like GitHub's Copilot have emerged, utilizing AI to provide coding suggestions based on natural language prompts, which significantly speeds up the programming process. On the other hand, writers now have access to autoregressive language models such as OpenAI's Chat GPT, which leverages deep learning to generate text that resembles human writing. These AI programs have rapidly evolved from their initial stages and have become widely used tools in the fields of writing and coding (Tewari, G. 2022).

2.6. Concerns Surrounding AI Risks and Potential Threats

With the proliferation of AI, concerns and claims about potential threats have surfaced. Some companies may exaggerate the capabilities and applications of their AI models, while proponents may promote science-fiction narratives that divert attention from immediate risks. Additionally, AI models themselves can inadvertently reproduce incorrect or misleading information. To effectively navigate the future, it is essential to develop a basic understanding of how these models operate and to differentiate between common myths and realities surrounding AI.

An open letter, signed by notable figures including Elon Musk, former Democratic presidential candidate Andrew Yang, and Tristan Harris from "The Social Dilemma," has called for a pause in the development of "giant AI experiments" such as the proposed large language model GPT-4. The letter raises concerns about the societal and existential risks associated with uncontrolled advancements in impressive AI systems. It hints at the potential emergence of "nonhuman minds" that could surpass, outsmart, render obsolete, and even replace human beings. However, the letter has also faced criticism, with some prominent AI researchers accusing the authors of misrepresenting the capabilities and risks of AI (Hunter, T. 2023).

3. TYPES OF AI

Four main types of Artificial Intelligence exist: Reactive Machines; Limited Memory; Theory of Mind; and Self-aware machines. Reactive Machines and Limited Memory, examples of Weak AI, both already exist and are actively used in today’s world, while

Theory of Mind and Self-aware types, considered Strong AI, are largely theoretical and are in the developmental stages.

3.1. Reactive Machines

Reactive Machines, one of the oldest forms of AI systems, have extremely limited capabilities according to Forbes. They have no memory and are largely task specific which means an input typically delivers the same output. Because they have no ability to learn, they can only be used for automatically responding to a limited set or combination of inputs. Widely known examples of Reactive Machines include Deep-Blue, IBM's chess-playing machine, which beat Garry Kasparov in 1997, and Netflix's recommendation engine which provides recommendations to consumers based on their historical viewing patterns.

3.2. Limited Memory

Limited memory machines build on the capacity of Reactive Machines with the ability to learn from historical patterns and data to make decisions. The algorithms that drive Limited Memory machines utilize the way the neurons of the human brain work together which results in more improved outputs upon receipt of more data. This use of deep learning drives improvements in areas such as image recognition and the ability to investigate the past and monitor specific objects or situations over time. According to Forbes, nearly all existing applications that we know of come under this category of AI. Almost all present-day AI applications from chatbots to virtual assistants to self-driving vehicles are all driven by limited memory AI.

3.2.1. Generative AI

Generative AI, a subcategory of Limited memory AI, refers to deep learning models that can take vast amounts of raw data and learn to generate statistically probable outputs when prompted (IBM 2023). The Boston Consulting Group (BCG) describes it as a set of algorithms, capable of generating seemingly new, realistic content such as text, images, or audio from training data.

According to NVIDIA, one of the world's leading software companies and dominant supplier of AI software and hardware, these capabilities have given organizations the ability to more easily and quickly leverage a large amount of unlabeled data to create foundation models which in turn can be used as a base for AI systems that can perform

multiple tasks. Examples of foundation models include GPT-3 and Stable Diffusion which allow users to leverage the power of language. Applications like ChatGPT draw on GPT-3 and allow users to generate an essay based on a short text request.

3.3. Theory of Mind

This type of AI is still in the developmental stages and is expected to give machines the ability to interact with humans, understanding their emotions, beliefs, and thoughts. The idea behind Theory of Mind is to create machines that can interact with humans more effectively because they understand their needs, goals, and motivations (Rodrigue & Needle, 2023). They theorize that if an AI system can understand the frustrations of a disgruntled customer, for example, it can respond more tactfully.

3.4. Self-aware

Like Theory of Mind, this type of AI also only exists hypothetically and would see machines having a sense of self and a conscious understanding of their existence as the name suggests. According to Forbes, this type of AI would not only be able to understand and evoke emotions in those it interacts with, but also have emotions, needs, beliefs, and potentially desires of its own. A vivid example of such may be seen in futuristic film “Ex Machina” (2014) which garnered some 161 nominations and 73 awards, including an Oscar for “Best Achievement in Visual Effects”. In the movie, a young programmer, gets a chance to become a part of a strange scientific experiment where he is expected to assess artificial intelligence by interacting with a female robot.

It is widely believed that the world is a long way from this type of AI because there are still so many unknowns about the human brain with respect to how memory, intelligence, learning and decision-making work.

4. APPLICATIONS OF AI

The global financial services industry is highly data driven at its core, generating vast repositories of structured and unstructured consumer and transaction data that is perfectly poised for leveraging AI-based applications and services (Kruse, et al., 2019). With this ever-increasing reliance on technology and its adaptations, consumer behaviour and lifestyle choices have been irreversibly altered toward an expectation of personalization and instantaneous results (Cao, 2023). As markets become increasingly competitive, financial institutions are then tasked with the challenge of retaining

customer satisfaction and loyalty while evolving by adapting modern technologies (Kruse, et al., 2019).

According to (Brown, 2023), as it relates financial management AI has predominantly been applied to niche applications. In the financial services industry, AI Implementation has largely taken the form of incorporating chatbots or robo-advisors into pre-existing mobile or social media interfaces as virtual customer assistants (Buchanan, 2019). Additional AI applications are being targeted toward algorithmic trading, market impact analysis, asset and wealth management, portfolio composition and optimization, model validation, risk management, credit scoring, fraud detection, cybersecurity, regulatory compliance, and stress testing (Hentzen, et al., 2022).

4.1. AI and Investment Management

The fundamental underpinning of investment management is the ability to consistently deliver above market returns for your clients as effectively and efficiently as possible. To accomplish this, investment managers employ techniques including robust data analysis to make quality decisions based on all available data. While tools and techniques are available to allow investment managers to conduct these tasks, AI and machine learning present a unique opportunity to boost efficiency and effectiveness in this regard.

A 2019 Harvard Business Review article summarized that machine learning could allow asset managers to identify potentially outperforming equities by finding new patterns in existing data sets, make new forms of data analyzable, and reduce the negative effects of human biases on investment decisions (Pozen & Ruane, 2019).

The operating environment for investment management firms continues to evolve, with technological innovations and shifting investor preferences at the heart of this change (Deloitte, 2023). According to U.S. News and World Report, the global market for artificial intelligence in asset management was worth about US2.6 billion in 2022 and is expected to expand at a compound annual growth rate of 24.5% from 2023 to 2030 according to analyst from Grand View Research.

A survey conducted by London-based market analytics and AI research specialist Market Makers revealed that nine out of ten hedge fund traders planned to use AI in 2023 (U.S. News and World Report, 2023) while a study by Forrester’s Future Fit Survey revealed that 62% of businesses and technology professionals at wealth

management firms anticipate increasing spending on emerging technologies over the next 12 months (Empaxis, 2023).

Findings from a 2023 survey conducted by PWC titled "Asset and Wealth Management Revolution 2023" revealed that 90% of institutional investors surveyed believe that disruptive technologies including AI will lead to better outcomes and portfolio returns (PWC, 2023). The survey also revealed great opportunities for growth in demand for wealth management with an estimated US68 trillion of generational wealth to be transferred to millennials by 2030, heightening the demand for tech-enabled services favored by younger people (Forbes, 2023).

In Deloitte Global's latest report, *Artificial Intelligence – The Next Frontier for Investment Management Returns*, they indicate that the use of AI can dramatically advance the ability to recognize patterns, anticipate future events, create good rules, make good decisions, and communicate with other people. They posit that the adoption of AI in investment management is now empowering firms to do things they couldn't do before: augmenting the intelligence of the human workforce and facilitating the development of next-generational capabilities.

4.2. Analysing Customer Data

Several notable investment firms have recognized the value and importance of integrating AI technology to improve their wealth management advisory services. Robo-advisors and chatbots apply machine learning algorithms to customer data to deduce individualized financial goals, risk tolerances and portfolio compositions which are then communicated to users through natural language processing (NLP) (Buchanan, 2019). The shift from transactional forms and fields to more conversational modalities provide customers with more innately natural interfaces that incorporate talking, writing, and gesturing across multiple platforms (Kruse, et al., 2019). As indicated in the Figure 3 below, the most significant challenges that abound in applying AI to the customer service function have to do with ensuring personalization, inaccuracies and integrating AI with existing systems and data (HubSpot, 2023).

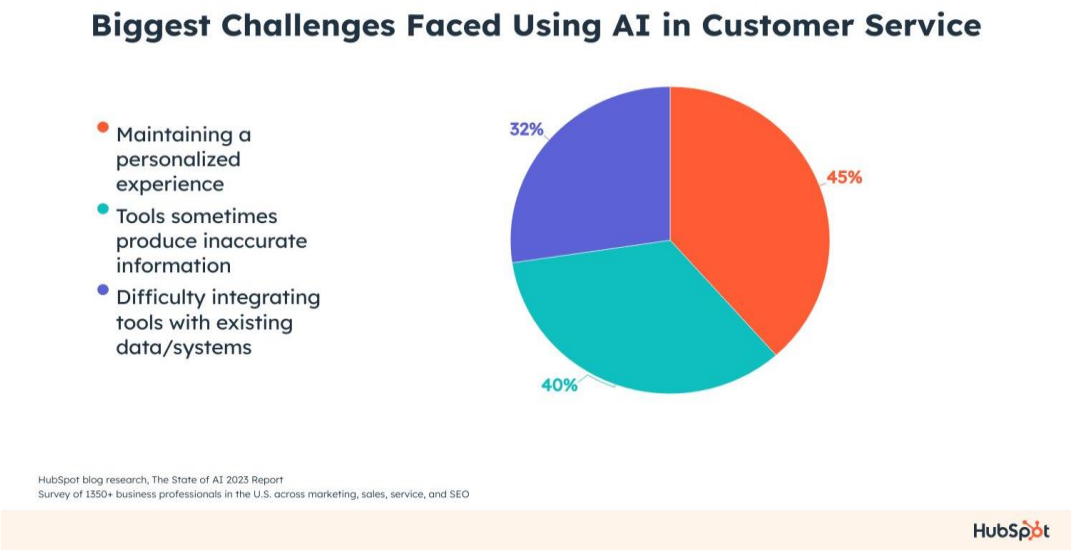


Figure 3 – Biggest Challenges Faced Using AI in Customer Service (HubSpot, 2023)

Vanguard's robo-advice platform called Digital Advisor is an all-digital low-cost investment solution that helps investors meet their financial goals by assessing risk appetite and automatically rebalancing portfolios (Forbes, 2023). With this service, there is a specific emphasis on providing financial solutions and management without any access to or use of financial advisors (FAs). While this approach translates into significantly lower fees for customers, they are in turn completely forfeiting the benefit of engaging with human intelligence for guidance and support. Despite this robo-advisors continue to enjoy explosive growth with overall assets under management (AUM) expected to surpass USD $4.5 trillion by 2027 (Statista, 2023). Figure 4 below highlights AUM and client bases of the top ten active robo-advisors in the US market (Forbes Advisor, 2022).

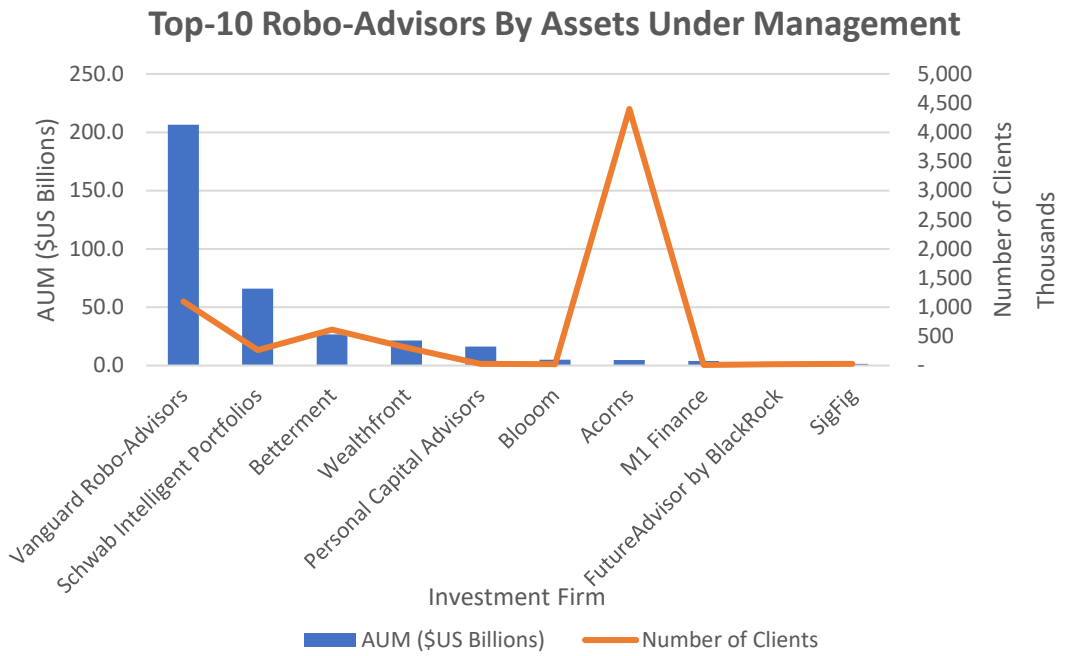
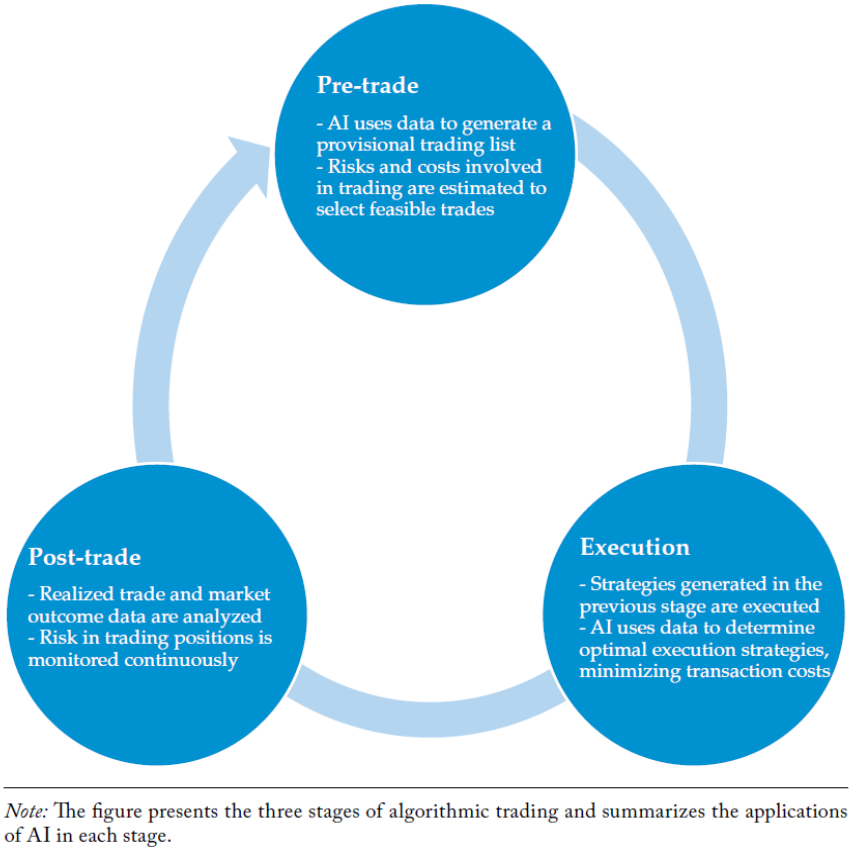


Figure 4 – Top-10 Robo-Advisors by Assets Under Management (Forbes Advisor, 2022)

By contrast, Morgan Stanley's Next Best Action (NBA) system combines machine learning intelligence with a traditional FA interface to convey personalized investment recommendations through increased client engagement (Davenport & Bean, 2021). The recommendations engine provides FAs with a range of pertinent general and specific investment-related talking points pertaining to each client's portfolio. The onus is then on the FA to engage the client by sending routine communication or initiating a conversation depending on the nature of the information at hand. The company leverages AI to determine specific topics that are of interest to clients in guiding the FA's human-based approach (Davenport & Bean, 2021). Having recognized the intrinsic value of frequent and relevant client engagement, Morgan Stanley has used AI to equip its FAs with a reliable tool that significantly improves customer trust and satisfaction, while simultaneously increasing FA efficiency and productivity (Forbes, 2020).

4.3. Trading

Algorithmic trading is an updated version of computer-based financial transaction that follows pre-defined programming to efficiently execute large-volume trades (Data Science Central, 2022). AI-based algorithms can be applied at all stages of the trading process, from pre-trade and post-trade analysis to trade execution as shown in Figure 5 below (Bartram, et al., 2020).



Note: The figure presents the three stages of algorithmic trading and summarizes the applications of AI in each stage.

Figure 5 – Algorithmic Trading with AI (Bartram, et al., 2020)

AI can therefore be leveraged across the board to drive strategy, make predictions, execute trades, and manage risk by using an array of techniques such as but not limited to algo wheels, probabilistic logic, evolutionary computation, and deep learning (OECD, 2021), which are further defined in the Table below. With lessening need for intervention, properly functioning AI effectively deepens its built-in learning and predictive capacity to significantly outpace human ability, while substantively lowering costs and processing times.

Table 1 – Some Algorithmic Trading Technique Definitions

Algorithmic Trading Technique	Definition
Algo Wheels or Algorithmic Trading Wheels	Algo wheels use algorithms on the buy-side to automate trade execution routing systems to ensure that orders are executed at the lowest transaction costs using the most effective brokers and strategies. The algorithm amasses a wealth of information on trade, broker, and order performance, and uses statistical analysis and machine learning to optimize orders based on the trader's specifications. (Bloomberg Professional Services, 2019; Marcos, 2023)

Probabilistic Logic	This involves factoring in statistical function probability distributions as a component of decision-making when considering trades.
Evolutionary Computation	Evolutionary computation encompasses genetic algorithms, which acquired the name from simulating processes that make up natural selection. As it relates to trading, the fittest financial strategies resulting in the highest profitability are continuously replicated and enhanced. (Medium.com, 2023)
Deep Learning	Deep learning is an AI method that processes complex data, as the human brain would, thereby recognizing patterns and synchronicities, and in so doing generates sophisticated understanding, insight, and predictions. In the context of trading, deep learning sifts through vast and noisy financial data to decipher key market signals and helps traders streamline algorithmic models. (Chen, et al., 2017)

One such example is BlackRock's proprietary investment management software platform, Aladdin, which stands for Asset, Liability and Debt and Derivative Investment Network. Over the past 30 years Aladdin has developed into a powerful and sophisticated network of supercomputers responsible for managing over $21 trillion in global assets, and in so doing has propelled BlackRock to being the world's largest investment manager (Business Insider, 2022). According to (KPMG, 2022), BlackRock recognized early on the value of harnessing information processing capabilities to ensure scalability. As a testament to this, Aladdin is now positioned as a major player in the global financial market steering BlackRock's daily investment activity, providing outsourcing solutions to other firms and governments, and charting the course in incorporating climate change and sustainability into the world's ever-evolving financial ecosystem (KPMG, 2022).

BloombergGPT is a generative financial Large Language Model (LLM) developed by Bloomberg that applies diverse NLP capabilities such as "sentiment analysis, named entity recognition, news classification, and question answering" (Bloomberg Professional Services, 2023). The extensive project utilized 363 billion tokens from Bloomberg's four decades of data sources along with 345 billion tokens from a general dataset in developing a model that significantly outperforms its counterparts (Wu, et al., 2023). BloombergGPT can now assess financial data to gauge positive or negative response to events, companies, or individuals. As a research and analysis tool, it can

provide deeper insight based on identifying patterns and trends that may not be immediately obvious to human analysts. Ultimately, BloombergGPT affords traders time-savings and improved accuracy in assessing risk and executing transactions.

4.4. Satellite Imagery

Sophisticated investment professionals are increasingly exploring AI-assisted satellite imagery in harnessing the power of commercial geospatial intelligence. RS Metrics first made alternative data available to the market in 2010 by using satellites, planes, and drones to accurately predict a company's revenues based on counting the number of cars in their parking lots using real-time imagery (The Atlantic Magazine, 2019). The retail-traffic data went on to be used by well-known brands such as Home Depot, Lowe's, McDonald's, and Walmart, with a UBS Investment Bank analyst even detecting that Walmart's stock was undervalued when compared to its parking lot activity (The Atlantic Magazine, 2019).

Geospatial analytics has since expanded into a multimillion-dollar industry, garnering global economic datasets on topics ranging from conventional business to climate change and food security (CNN Money, 2018). Commercial satellite growth has exploded in recent years and is predicted to continue at incredible pace with an average of 1,700 satellites expected to be launched every year until 2030, representing "a fourfold increase over past decade" (Euroconsult, 2021). Figure 6 below highlights the exponential increase in commercial satellites launched in the United States alone (The U.S. Geological Survey, 2023).

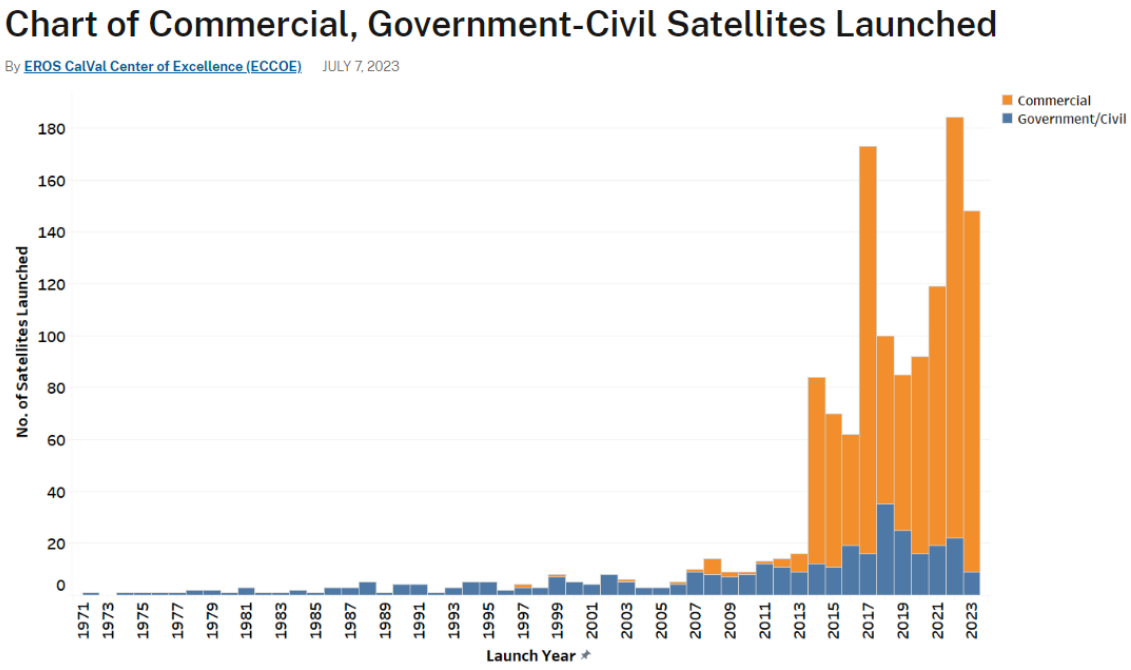


Figure 6 – Chart of U.S. Commercial, Government-Civil Satellites Launched (The U.S. Geological Survey, 2023)

Orbital Insight is another giant in the field, combining satellite imaging, AI, and machine learning to provide its global clientele with real-time economic, societal, and environmental data for more informed decision-making (Orbital Insight , 2023). The company is known for equipping hedge fund managers with key estimates of the global crude-oil supply ahead of normal disclosure channels (Impact Lab, 2017). This was achieved by having an algorithm assess the correlation between oil tank lids and the depth of shadows they cast, which in turn indicated real-time oil levels and the corresponding volume held in any given tank. Hedge Funds benefited from this edge on the market as managers were then equipped with information to make investment decisions that led to outperformance through consistent profits and positive results (BerkeleyHaas, 2019).

As it stands, geospatial technology is expected to continue to improve by becoming faster, and even more accurate, intelligent, and cost-effective over time (CNN Money, 2018). There is still, however, the question of informational accessibility as alternative data has not traditionally been available to individual investors, thereby creating unfair advantages for institutional investors who have vast resources geared toward acquiring expensive specialized expertise and cutting-edge technologies (BerkeleyHaas, 2019).

Additionally, matters continue to abound regarding privacy of public and private information. BerkeleyHass (2019) posits that regulators need to level the playing field for individual investors to ensure that the integrity of the capital markets is retained in the years to come.

4.5. Use Cases: Financial Reporting

Manually preparing company reports such as Annual Reports requires significant time and effort specifically as it relates to gathering, consolidating, and analysing data from multiple sources. As companies expand and generate more data, the task becomes increasingly more difficult. Fortunately, AI technologies, such as machine learning and natural language processing, can be used to automate data collection, data analysis, and the report generation process. Additionally, AI can be used to process, extract, and summarize valuable information from large volumes of financial documents such as annual reports, financial statements, and earnings calls. This can facilitate more efficient analysis and decision-making by the end user. Some cases where companies utilize and/or provide solutions using AI technology in this regard include:

1. Alphasense – This AI-powered search engine, tailored for the finance industry, serves clients such as banks, investment firms as well as other Fortune 500 companies. The platform utilizes natural language processing to analyse keyword searches within filings, transcripts, research, and news to discover changes and trends in financial markets. It is particularly valuable to a variety of financial professionals and companies. The search engine provides brokers and traders with access to SEC and global filings, earning call transcripts, press releases and information on both private and public companies.
2. JP Morgan Chase – JP Morgan Chase has been successfully utilizing Robotic Process Automation (RPA) by performing tasks such as extracting data, complying with Know Your Customer (KYC) regulations, and capturing documents.
3. Kensho – created machine learning training and data analytics software that can assess thousands of datasets and documents. Its data training software uses a combination of machine learning, cloud computing and natural language processing, and it can provide easily understandable answers to complex financial questions as well as extract insights from tables and documents quickly. According to Forbes, traders with access to Kensho's AI-powered database in the days

following Brexit used the information to quickly predict an extended drop in the British pound.

4. KlearStack – KlearStack uses advanced AI algorithms to accurately interpret complex financial statements, tables, and graphs found in annual reports while also being able to recognize and extract data consistently across varying formats, layouts, and languages. KlearStack's machine learning algorithms can also detect missing or incomplete data and accurately fill in the gaps where possible.
5. Snorkel Flow – This company provides solutions to clients by extracting critical data such as structured financial data from balance sheets and income statements from companies' quarterly and annual reports in milliseconds using a financial spreading application that parses textual and spatial/visual data features.

4.6. Use Cases: Investment Research

Some cases where companies utilize and/or provide solutions using AI technology with respect to investment research include:

6. Alpaca Forecast AI Prediction Matrix – Created by Bloomberg, this price-forecasting application for investors is powered by AI. It combines real-time market data provided by Bloomberg with an advanced learning engine to identify patterns in price movements for high-accuracy market predictions.
7. Kavout – Kavout uses machine learning and quantitative analysis to process huge sets of unstructured data and identify real-time patterns in financial markets. One of Kavout's solutions is the K Score, an AI-powered stock ranker. The K Score analyses massive amounts of data, such as SEC filings and price patterns, then condenses the information into a numerical rank for stocks. The higher the K Score, the more likely the stock will outperform the market.
8. Morgan Stanley – Morgan Stanley employs OpenAI-powered chatbots to support financial advisors by utilizing the company's internal collection of research and data as a knowledge resource.
9. Q.ai – A Forbes company, Q.ai provides users with automated financial advice by using powerful deep-learning technology to make trades on an investor's behalf. It builds and manages thematic "Investment Kits" which offer exposure to a wide variety of investing strategies, powered by advanced AI algorithms. They span from "Foundation" Investment Kits, which focus on traditional investing strategies, to "Limited Edition" and "Specialty" Investments Kits that allow you to perform

short-term trades and specialized investing themes. Once the portfolio is built using one or more Investment Kits, the AI tool automatically manages, rebalances, and trades the different holdings in each Investment Kit to help maximize returns and minimize losses.

5. QUANTITATIVE INVESTMENT MANAGEMENT

Quantitative (or quant) investing uses algorithms to analyze massive amounts of data (such as valuations, quality, liquidity, yields and the speed of price changes) and then systematically makes trades based on this analysis. This means that trades are grounded in historical data (Morgan Stanley, 2022).

A Quantitative Hedge Fund is any Hedge Fund that relies upon algorithmic or systematic strategies for implementing its trading decisions. Quant trading strategies may focus on any asset class (equities, derivatives, fixed income, foreign exchange, commodities, etc.), with trades that are based on systematic strategies, rather than discretionary decisions. In other words, at least to some degree, Quantitative Hedge Funds employ "automatic" trading rules rather than ones that employees at the fund identify and evaluate. Of course, these two strategies can be mixed, but nearly all Hedge Funds are either primarily a Quant Hedge Fund or primarily a non-Quant Hedge Fund (Streetofwalls, n.d.).

5.1. The History of Quantitative Investment Management

One of the founding fathers of the study of quantitative theory applied to finance was Robert Merton. One can only imagine how difficult and time-consuming the process may have been before the use of computers. Other theories in finance also evolved from some of the first quantitative studies, including the basis of portfolio diversification based on modern portfolio theory.

The use of both quantitative finance and calculus led to many other common tools, including one of the most famous, the Black-Scholes option pricing formula, which not only helps investors price options and develop strategies but helps keep the markets in check with liquidity.

When applied directly to portfolio management, the goal is like any other investment strategy: to add value, alpha, or excess returns. Quants, as the developers are called, compose complex mathematical models to detect investment opportunities. There are

as many models out there as quants who develop them, and all claim to be the best. One of the best-selling points of a quant investment strategy is that the model, and ultimately the computer, makes the actual buy/sell decision, not a human. This tends to remove any emotional response that a person may experience when buying or selling investments.

Quant strategies are now accepted in the investment community and are run by mutual funds, hedge funds, and institutional investors. They typically go by the name "alpha generators" or "alpha gens" (Schmidt, 2023).

5.2. Advantages of Quant Strategies

Low management fees afforded by quant funds, which largely cannot be matched by human-managed active funds, are a primary advantage of quant strategies. Cost efficiency is one reason why Vanguard, the inventor of the index fund, ascended through the decades to reach the brink of being the world's largest asset manager.

While the overall success rate is debatable, the main reason some quant strategies work is that they are based on discipline as opposed to human interpretation of market conditions which may be colored by human sentiment and biases. If the model is efficient, the discipline keeps the strategy working with machines and programs to exploit inefficiencies in the securities markets based on historical quantitative data. The models themselves may be based on ratios like price to earnings, debt-to-equity, and earnings growth, or they may be more complex, utilizing thousands of inputs working together simultaneously.

Successful strategies can pick up on trends in their early stages as computers constantly run scenarios to locate inefficiencies in the market before humans do. Models are designed to be capable of analyzing a large group of investments simultaneously, where the traditional human analyst may be looking at only a few at a time. As quant strategies are implemented using algorithms, it also reduces the risk of human error as an individual is not executing the strategy.

Successful quant funds keep a keen eye on risk control due to the nature of their models. Most strategies start with a universe or benchmark and use sector and industry weightings in their models. This allows the funds to control the diversification to a certain extent without compromising the model itself. Quant funds typically run on a

lower cost basis because they don't need as many traditional analysts and portfolio managers to run them.

5.3. Disadvantages of Quant Strategies

There are reasons why so many investors do not fully embrace the concept of letting a "black box" run their investments.

While a strong quant team will be constantly adding new aspects to the models to predict future events, it's impossible to predict the future every time. Quant funds can also become overwhelmed when the economy and markets are experiencing greater-than-average volatility. The buy and sell signals can come so quickly that high turnover can create high commissions and taxable events.

Quant funds can also pose a danger when they are marketed as bear-proof , that is to say, the strategies are designed to take into account market activity and will generate results even in a bear market. They can also be dangerous when they are based on short strategies. Shorting is a strategy used when an investor anticipates that the price of a security will fall in the short term. Attempting to predict downturns using derivatives and combining leverage can be dangerous.

Another negative is that with the increased usage of artificial intelligence, different quantitative funds may inevitably start making the same decisions in unison, which could bring about contagion issues for financial markets (Chandra, 2020).

One must also consider the volume of historical data that has to is required to develop quant strategies and models. If historical data is not readily available from reliable sources, designing and implementing quant strategies would not be possible as models designed with inaccurate, incomplete information will most likely produce inefficient, unreliable results.

5.4. Examples of Quantitative Investment Funds

Some examples of Quantitative Investment Funds include:

- Acadian
- AlphaSimplex
- AQR
- Bridgewater
- Citadel

- Capula
- D.E. Shaw, Renaissance
- Man Group
- Millennium
- PanAgora
- Point72 (formerly SAC)
- Quantitative Management Associates
- Two Sigma

Some of the larger ones, such as Bridgewater and Citadel, do a lot more than just "quantitative investing," so they are not dedicated quant funds (Mergers and Acquisitions, 2022).

The following is an excerpt from an article on Investopedia relating to failed hedge funds. "Long-Term Capital Management (LTCM) was one of the most famous quant hedge funds, as it was run by some of the most respected academic leaders and two Nobel Memorial Prize-winning economists, Myron S. Scholes, and Robert C. Merton. During the 1990s, their team generated above-average returns and attracted capital from all types of investors. They were famous for not only exploiting inefficiencies but using easy access to capital to create enormous leveraged bets on market directions.

The disciplined nature of their strategy created the weakness that led to their collapse. Long-Term Capital Management was liquidated and dissolved in early 2000. Its models did not include the possibility that the Russian government could default on some of its own debt. This one event triggered other events, and a chain reaction, magnified by leverage, created havoc. LTCM was so heavily involved with other investment operations that its collapse affected the world markets, triggering dramatic events.

In the long run, the US Federal Reserve stepped in to help, and other banks and investment funds supported LTCM to prevent any further damage. This is one of the reasons quant funds can fail, as they are based on historical events that may not include unforeseen, "black swan" future events." (Schmidt, 2021).

5.5. Growth of Quant Funds

Sankaranarayanan Krishnan, Quant Fund Manager, Portfolio Management Services (PMS) and Alternate Investment Funds (AIF) schemes, Motilal Oswal Asset

Management Company says many fund houses have started incorporating quantitative methods. “They have a quant desk or one or two people who are working on quant strategies. There is an incremental interest as to how it evolves, and no one wants to be left behind. There are a few firms that have done more than others, but others are trying to catch up,” explains Krishnan (Forbes India, 2023).

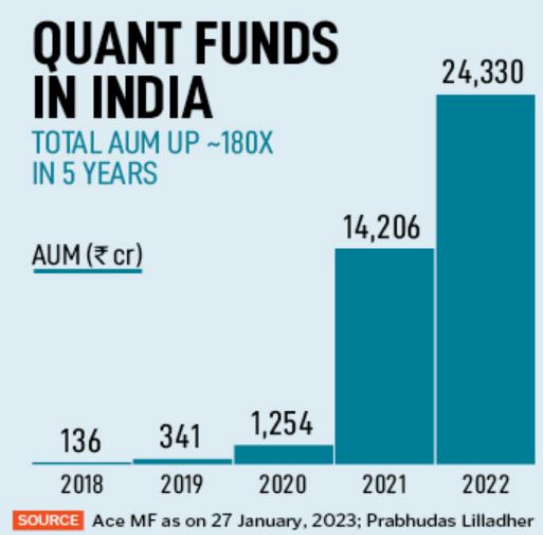


Figure 7 – Quant Funds in India (Ace MF, 2023)

As of 2019, ETFs and index funds, essentially passive asset management, together manage more US equities than funds that are actively-managed. Across the $31 trillion of US stock market value, quant funds now control 35.1% of market capitalization, compared to 24.3% of human, actively-managed funds.

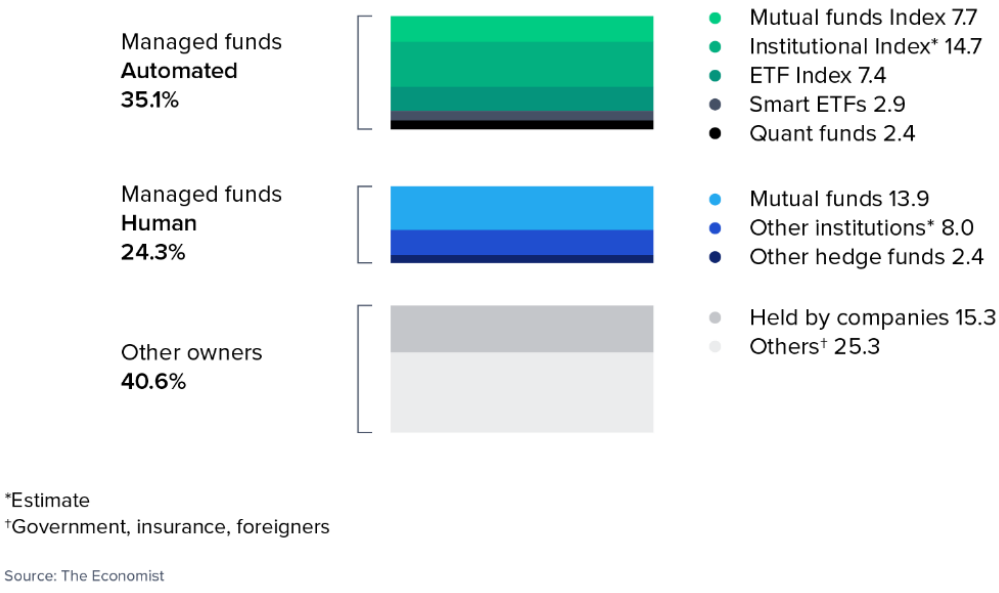


Figure 8 – Automated vs Human Managed funds in the US (Source, The Economist)

5.6. *Historical Performance of Quant Funds*

According to Aurum, Quant Deep Dive August 2022, "Quant has exhibited exceptional positive performance over the 12 months to August 2022, delivering an average return of 12.8%. The strategy was positive for 9 of those 12 months, with the worst monthly drawdown in July 2022 when the master strategy was down 2.1%. The best monthly return for the period was 3.9% followed closely by 3.7% in March 2022 and April 2022 respectively."

The second largest strategy monitored by Aurum's Hedge Fund Data Engine by AUM is quant, accounting for $445bn out of $3,143bn combined AUM monitored as at August 2022. The quant master strategy AUM over the period grew by $42.8bn; the growth was primarily due to net profits of $47.8bn with net outflows of $5.0bn, while the total number of quant funds monitored decreased by seven funds from 483 funds to 476 funds.

At the sub-strategy level, quant macro, CTA and statistical arbitrage outperformed, while risk premia and quant equity market neutral were more challenged. Both quant macro and CTA were well positioned for rising inflationary pressures through long positions in commodities, US dollar, and short fixed income. Statistical arbitrage benefited from elevated intra-month stock volatility and increased cross-sectional dispersion (Aurum, 2023).

NET RETURN OF MASTER AND SUB STRATEGIES (1 YR)

Net Performance	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	YTD	1 YR
Quant	**0.1%**	**1.2%**	**-1.2%**	**2.6%**	**0.9%**	**0.7%**	**3.9%**	**3.7%**	**-0.4%**	**1.3%**	**-2.1%**	**1.5%**	**9.9%**	**12.8%**
Quant Macro	1.7%	0.4%	-1.4%	2.8%	2.8%	0.5%	4.0%	6.2%	-0.6%	3.4%	-3.9%	3.4%	16.5%	20.6%
CTA	-0.1%	2.6%	-3.2%	0.9%	0.7%	2.3%	6.6%	4.5%	-0.2%	1.3%	-3.0%	2.7%	15.6%	15.9%
Stat Arb	1.7%	0.1%	1.1%	1.2%	1.5%	0.3%	2.1%	1.8%	-0.5%	1.2%	1.1%	1.4%	9.0%	13.5%
Quant EMN	-2.3%	1.1%	0.3%	6.1%	-1.3%	-1.0%	2.5%	1.9%	-1.3%	1.4%	-1.6%	-3.1%	-2.6%	2.4%
Risk Premia	-2.0%	0.6%	0.2%	3.3%	-0.4%	-0.1%	0.0%	-1.1%	1.0%	-4.9%	2.5%	-2.7%	-5.6%	-3.7%
HF Composite*	**-0.1%**	**1.1%**	**-1.2%**	**1.0%**	**-1.6%**	**-0.4%**	**0.9%**	**-0.6%**	**-1.0%**	**-1.7%**	**1.1%**	**0.6%**	**-2.7%**	**-1.9%**
Bonds**	**-1.9%**	**-0.3%**	**-0.5%**	**-0.2%**	**-2.3%**	**-1.3%**	**-2.9%**	**-5.6%**	**0.2%**	**-3.3%**	**1.9%**	**-3.9%**	**-16.1%**	**-18.6%**
Equities***	**-4.1%**	**4.6%**	**-2.9%**	**3.8%**	**-5.3%**	**-2.4%**	**1.7%**	**-8.1%**	**-0.2%**	**-8.7%**	**6.9%**	**-3.6%**	**-19.0%**	**-18.0%**

*HF Composite = Aurum Hedge Fund Data Engine Asset Weighted Composite Index. **Bonds = S&P Global Developed Aggregate Ex Collateralized Bond (USD). ***Equities = S&P Global BMI.

Figure 9 – Hedge Fund Performance by Investment Strategy (Aurum,2022)

Historical performance data shows that the performance of directional quant funds relative to a traditional 60/40 equity-to-bond portfolio has improved during periods such as these, when rates rise (Burns, 2022).

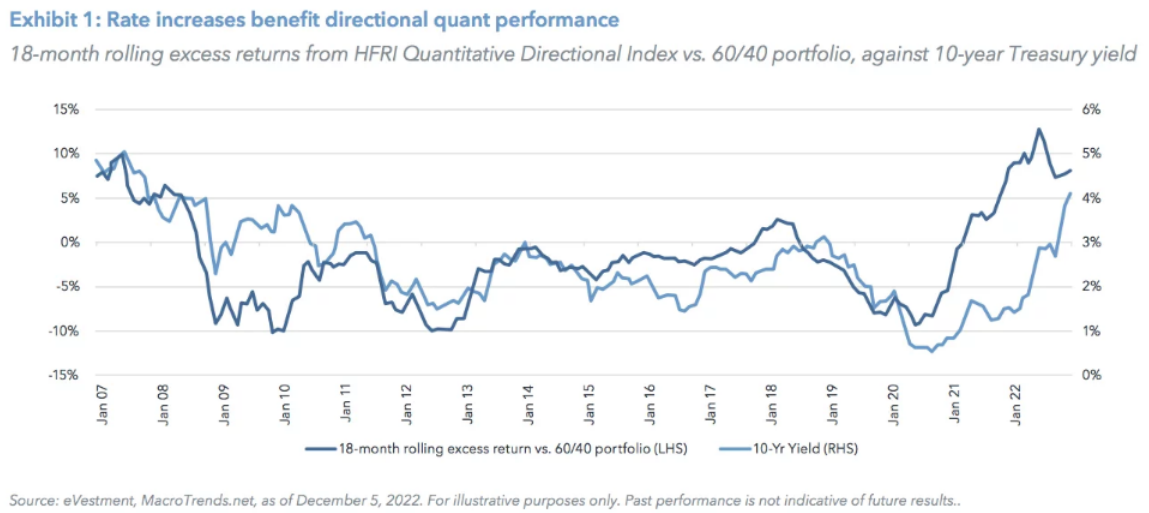


Figure 10 – Relationship between rate increases and quant performance in the US (Source, eVestment)

5.7. Quant Fund Example – Taaffeite Capital Management

According to their website, "Taaffeite Capital Management is a quant macro hedge fund focus on developing a high-quality globally diversified portfolio for sophisticated investors, family offices, global institutions, and investment banks. Delivering superior investment returns is what drives us.

Taaffeite Capital Management Liquid Alpha Program is a macro multi-strategy, allocating to 100-200 opportunities across global equities, fixed income, commodities, and currencies. This broad diversification aims to give investors exposure to a broad set of global opportunities, and Taaffeite aims to select the highest quality assets within each asset class to produce significant returns.

Since 2013, Taaffeite Capital has developed quantitative techniques to make high-quality price predictions and build high-quality global portfolios to outperform our peers. Over a 3-year rolling window, Taaffeite aims for all asset classes to contribute to returns and therefore aims to outperform a common index like the S&P 500.

Our fund aims to beat our benchmarks on a risk-adjusted basis over 2 to 3-year rolling windows. TCM benchmarks against MSCI All-Country World Equity Index and the HFR Systematic Macro Index."

TCM Performance Table (%)*

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
2022	TCM	-13.72%	1.24%	1.29%										**-11.52%**
	ACWI	-4.55%	-3.06%	1.94%										-5.68%
2021	TCM	4.98%	-7.19%	-9.33%	4.84%	0.29%	9.04%	20.60%	1.86%	-16.93%	0.50%	2.97%	-2.61%	**4.16%**
	ACWI	-0.31%	2.29%	2.85%	4.25%	1.47%	0.54%	0.91%	2.17%	-4.23%	5.39%	-2.31%	2.82%	16.59%
2020	TCM	15.63%	-12.47%	-19.46%	6.35%	13.07%	10.09%	17.14%	16.55%	6.56%	0.38%	19.82%	4.40%	**97.15%**
	ACWI	-1.44%	-7.49%	-13.41%	9.83%	5.09%	2.08%	5.36%	6.03%	-2.95%	-2.23%	11.76%	3.88%	14.47%
2019	TCM	-0.24%	-0.06%	0.36%	-1.13%	-0.20%	-2.27%	-0.10%	-5.27%	3.01%	-13.91%	5.39%	-5.27%	**-19.16%**
	Sys Macro Index	-9.08%	-2.13%	1.21%	-1.61%	4.68%	-2.02%	2.34%	5.90%	-5.44%	-4.92%			-11.44%
	ACWI											2.34%	2.21%	4.60%
2018	TCM	-8.03%	11.14%	3.87%	-6.89%	-3.38%	4.24%	1.97%	6.87%	-9.30%	-1.62%	-4.10%	0.69%	**-6.52%**
	Sys Macro Index	-1.84%	-1.88%	1.05%	-0.37%	-1.49%	1.74%	-3.67%	1.21%	-1.44%	3.62%	-2.19%	9.47%	3.61%
2017	TCM	9.90%	4.24%	-4.09%	0.92%	-2.37%	6.66%	-2.14%	2.25%	-1.84%	-1.82%	4.56%	1.99%	**18.74%**
	Sys Macro Index	-4.13%	-1.12%	-2.70%	-1.50%	-1.76%	-1.50%	-1.78%	0.70%	-3.78%	1.47%	-2.04%	0.41%	-16.49%
2016	TCM	1.47%	-14.06%	-0.37%	-2.40%	7.71%	33.23%	1.66%	5.05%	11.38%	-4.32%	1.66%	-4.33%	**34.68%**
	Sys Macro Index	7.80%	3.90%	-9.46%	-2.18%	-2.12%	4.91%	-2.72%	-3.20%	-1.84%	-0.80%	-1.80%	0.04%	-8.24%
2015	TCM	-3.91%	0.25%	-1.58%	2.64%	-6.28%	8.69%	18.74%	1.24%	7.47%	14.68%	-1.52%	7.46%	**55.39%**
	Sys Macro Index	5.72%	-5.88%	2.20%	-5.26%	-0.46%	0.29%	0.71%	4.63%	4.47%	-8.67%	2.88%	0.99%	0.47%
2014	TCM	-7.38%	12.48%	3.41%	0.93%	7.65%	1.24%	-4.98%	2.04%	-18.75%	1.59%	5.72%	-0.97%	**-0.71%**
	Sys Macro Index	2.94%	-3.45%	-2.19%	-1.17%	-1.03%	0.35%	0.98%	0.17%	5.58%	-0.85%	2.70%	4.39%	8.32%
2013	TCM							2.72%	-2.22%	9.34%	8.36%	3.69%	0.08%	**23.49%**
	Sys Macro Index							-5.49%	0.88%	-6.02%	-2.66%	-0.46%	-0.71%	-13.80%

*Actual investor returns after all fees and expenses

Figure 11 – TCM Liquid Alpha Program Performance (Source, Taaffeite)

Based on data available on Bloomberg. If one were to invest in TCM in 2013 and exit at the end of 2022, that investor would have earned a 122% return on the initial investment with reinvested dividends.

Figure 12 – TCM Global Index Fund A (Machine US Equity) Performance (Bloomberg, 2023)

5.8. Quantitative Investment Strategies and AI

"The lines are blurring between the quantitative and machine learning/artificial intelligence (AI/ML) investment approaches. Quant strategies typically start from human intuition while AI/ML models try to derive unique insights that humans overlook. Ultimately both only succeed if persistent and causal relationships are

captured accurately" according to Ben Dunn, Head of Quantitative Strategies, Eastspring Investments.

While the synergies are obvious, AI's application for process automation and marketing has been more popular than for picking stock winners. A 2019 survey by the CFA Institute found that only 10% of portfolio manager respondents had used AI/ML techniques in the previous 12 months. There remain skeptics as to how to incorporate AI methods into an investment process when the output of many modeling approaches may not make intuitive sense from a human investor's standpoint (Eastspring, 2022).

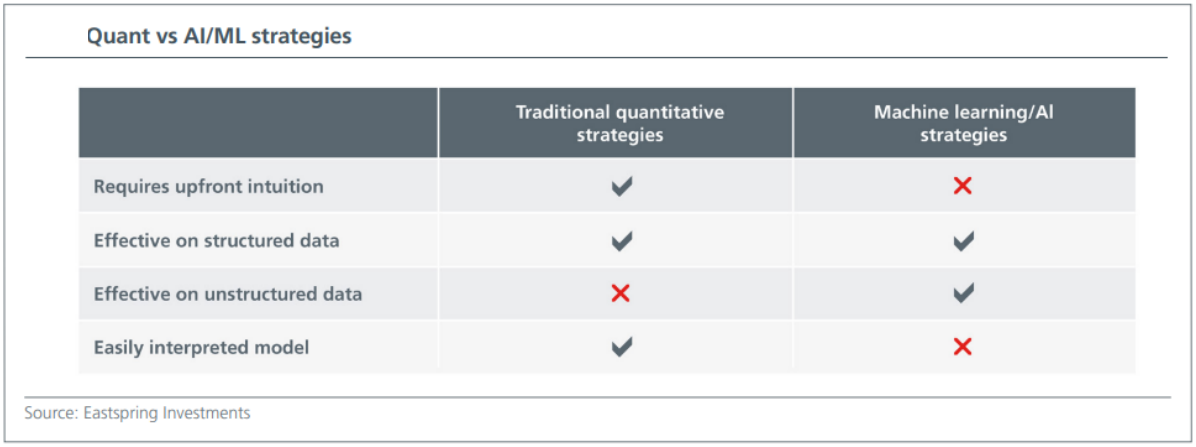


Figure 13 – Comparison of Features of Quant vs. AI/ML Strategies (Source, Eastspring Investments)

Investment professionals will work with AI tools and techniques to improve efficiencies and benefit from exploiting large amounts of data to make informed decisions. Over time, letting a machine learn from expert investors and using the algorithm to extend the breadth of coverage may be the most fruitful avenue. The use of AI may allow asset managers to spend more time developing strategies, identifying new data sources, updating algorithms, and interpreting their results. Using AI/ML models to complement existing ones may ultimately help to better manage portfolio risks.

6. DISCUSSION

With Artificial Intelligence (AI) being actively used in global investment firms, a perspective was designed for the new paradigm of investment management. The writing team, after completing the research of Artificial Intelligence around the world in investment management, discussed how an investment management team would operate with AI in the English-speaking Caribbean. In this case, the country selected was Trinidad and Tobago.

Figure 14 displays the organizational chart of a hypothetical AI driven investment management firm in Trinidad and Tobago, Company XYZ (XYZ).

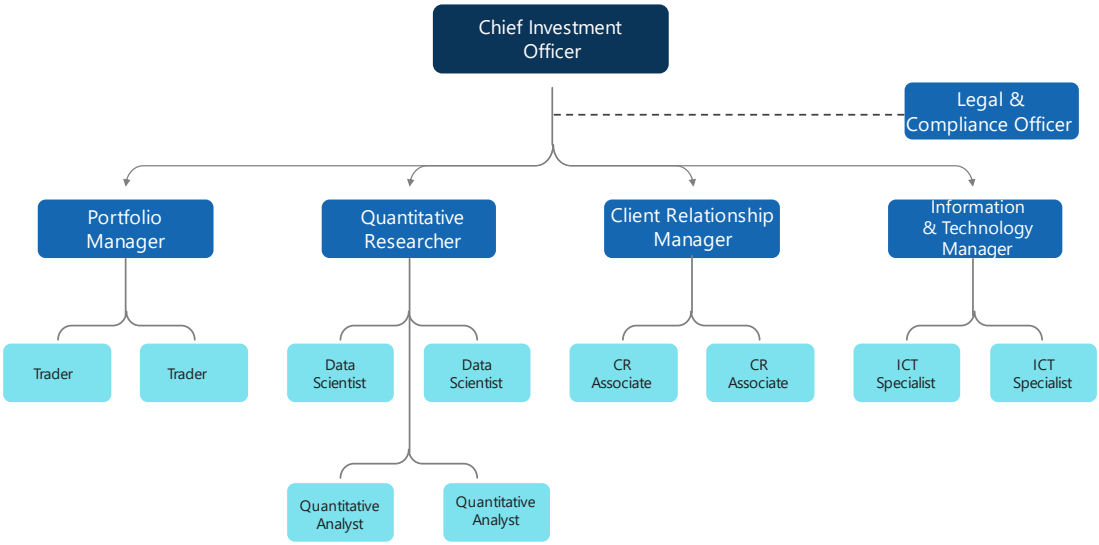


Figure 14 - XYZ Investment Management Firm Organizational Chart

6.1. Firm Overview

XYZ Investment Management is a leading firm operating in Trinidad and Tobago, specializing in providing comprehensive financial advisory and portfolio management services to clients. With a strong commitment to innovation and staying at the forefront of technological advancements, XYZ has embraced the transformative potential of AI in finance and investment management.

6.2. Key Personnel

The team of XYZ consists of a team of experienced professionals who combine their financial expertise with AI-driven strategies to deliver exceptional investment returns and customer service. The key personnel within the firm include:

1. Chief Investment Officer (CIO): The CIO oversees XYZ's investment strategies and ensures alignment with client objectives and market trends. The CIO will read reports that were generated by AI that analyzed vast amounts of market data to identify market trends and make data-driven investment decisions. Through using AI, the CIO will be assisted in predicting future price movements and assessing the risks associated with the various investment strategies that the team is using. The

CIO is responsible for integrating AI tools and algorithms into the firm's processes, driving innovation, and fostering a culture of excellence (Tyagi, 2022).

2. Legal & Compliance Officer: The Legal & Compliance Officer is responsible for ensuring that the firm complies with all the relevant laws and regulations in Trinidad and Tobago. The Officer will use AI to automate compliance checks and identify legal risks. In a much larger firm, this function would have a larger team with an established and independently run Enterprise Risk Management Framework. This framework will encompass the entire firm, and cover the management of financial and operational risks. (Lorè, 2023).

3. Portfolio Manager (PM): The Portfolio Manager is responsible for XYZ's proprietary portfolio as well as clients' portfolios. The PM will work closely with the client to understand their investment goals, risk tolerance, and preferences. They will collaborate with the Data Scientists to optimize portfolios using AI-driven strategies. Also, the PM uses AI to optimize portfolio allocation based on risk and return predictions. Additionally, AI will help the PM to monitor the performance of the portfolios and make necessary adjustments in real-time (Huang, 2020; Conlon, 2021).

4. Quantitative Researcher: This person uses mathematical and statistical methods to analyse financial data and trends. The Quantitative Researcher uses AI to develop predictive models and algorithms that can help the firm to identify profitable investment opportunities (CFA Institute, 2021).

5. Client Relationship Manager (CRM): This role acts as the primary point of contact for clients, ensuring effective communication and addressing client queries and concerns. The CRM uses AI to analyze client data and provide personalized investment advice. Also, the CRM will use AI to help them monitor client satisfaction and predict client behaviour (Capponi, 2019).

6. Information & Technology Manager (IT): The IT manager is responsible for managing XYZ's IT infrastructure. AI will be utilized by the IT Manager to improve

the firm's IT systems and processes. AI will help the IT manager identify and resolve technical issues more quickly and efficiently (OECD, 2021).

7. Trader: This person is responsible for buying and selling financial instruments on behalf of the firm. The trader will use AI to make real-time trading decisions based on the data in various markets. AI will help the traders in the firm execute traders more quickly and accurately.

8. Data Scientist: This role possesses specialized skills in AI, machine learning and statistical modelling. The Data Scientist will leverage these capabilities to develop sophisticated algorithms, perform data analysis, and generate valuable insights to support the PM and CIO in making investment decisions. The person will use AI to analyze large volumes of financial data and develop predictive models. AI can also help the person in this role to identify patterns and trends that might not be visible to the human eye (CFA Institute, 2021).

9. Client Relationship Associate: The Client Relationship Associate supports the CRM in managing client relationships. It is expected that the Associate will use AI to analyse client data and provide a premium personalized service. The Associate will also use AI to help them identify opportunities to upsell or cross-sell XYZ's products and services (Capponi, 2019).

10. ICT Specialist: This role is responsible for managing the firm's ICT systems. AI will be used to improve XYZ's ICT infrastructure and processes. The ICT specialist will use AI to identify and resolve technical issues more quickly and efficiently (OECD, 2021).
11. Quantitative Analyst: This person uses mathematical and statistical methods to analyse financial data and trends. The Quantitative Analyst will use AI to develop predictive models and algorithms that can help the firm identify profitable investment opportunities (CFA Institute, 2020).

6.3. XYZ's Competencies and Capabilities

Firm XYZ, a forward-thinking investment management firm, has harnessed the power of AI to revolutionize its operations and enhance its core competencies. Through AI

integration, the firm has empowered its professionals to operate at an unprecedented level of efficiency and precision. The use of AI has significantly improved decision-making processes, enabling the team to make data-driven decisions with a higher degree of accuracy and speed.

AI enables automated data gathering and analysis from vast amounts of financial data, news, and social media sentiment. It helps identify patterns, trends, and anomalies that can inform investment decisions. AI-powered algorithms can analyse historical data, detect correlations, and generate predictive models to support XYZ's investment research and analysis (IMF, 2021; CFA Institute, 2021; OECD, 2021).

Firm XYZ will also be capable of improved portfolio optimizations. Its AI algorithms will assist in constructing optimal portfolios by considering various factors such as risk tolerance, investment goals, and market conditions. These algorithms can perform complex calculations and simulations to determine the best asset allocation strategies, considering factors like diversification, risk-adjusted returns, and constraints specific to XYZ or its clients (CFA Institute, 2020).

Also, XYZ will be able to automate the generation of detailed financial reports, reducing the time and effort required to compile and analyse financial data. XYZ's algorithms can process vast amounts of its internal and external data to generate insights into firm and portfolio performance, investment returns, risk metrics, and other key financial indicators. These reports can be customized to meet the specific needs of different stakeholders, including the CIO, the Portfolio Managers, clients, and regulatory bodies. Indeed, XYZ's use of AI can also enhance the accuracy and reliability of financial reports by detecting errors and inconsistencies in financial data. It can analyse historical data to identify patterns and trends that can inform future investment decisions. Moreover, XYZ's AI powered predictive analytics can provide forecasts of future financial performance based on historical data and market trends (OECD, 2021; IMF, 2021).

Real time reporting can be facilitated, enabling the Portfolio Manager at XYZ to monitor portfolio performance, and making informed decisions on the fly. Real-time reports can provide up-to-date information on markets trends, portfolio returns, risk levels, and allowing for timely adjustments to investment strategies (OECD, 2021; IMF, 2021).

The Traders' skills will also be amplified at XYZ. These traders will utilize AI algorithms in their trading systems to execute trades on predefined criteria. These algorithms can analyse market data, identify patterns, and execute trades with high speed and precision. AI-based systems can also employ machine learning techniques to continuously adapt and optimize trading strategies based on changing market conditions (OECD, 2021; IMF, 2021).

The Legal & Compliance function will incorporate AI to detect fraudulent activities by analysing XYZ's transactional data and identifying suspicious patterns. It will help XYZ comply with its regulations by monitoring transactions, identifying potential violations, and generating alerts for further investigation (OECD, 2021; IMF, 2021).

Firm XYZ will have improved customer service and personalized client recommendations as well. AI-powered chatbots and virtual assistants enable personalized customer interactions, answering queries, providing investment recommendations, and assisting with account management. XYZ's customer relationship management AI systems can analyse client preferences, investment history, and market trends to offer tailored advice and support (OECD, 2021; IMF, 2021).

Finally, XYZ will have its AI algorithms process unstructured data from alternative sources, such as social media, satellite imagery, and Internet of Things (IoT) devices, to gain insights into market trends, consumer behaviour, and industry dynamics. This information will help XYZ generate investment signals or inform investment strategies (OECD, 2021; IMF, 2021).

Overall, AI has transformed XYZ's finance and investment management by improving efficiency, accuracy, and decision-making capabilities. It empowers professionals of XYZ to make data-driven decisions, automate repetitive tasks, and leverage vast amounts of information to optimize portfolios and manage risks effectively.

6.4. Day in the Life of XYZ

A typical day in the of XYZ is as follows:

In the morning of the CIO begins the day by reviewing the AI-generated market analysis reports. This will enhance his knowledge for the upcoming day. Also, the CIO will be quickly briefed by the various teams to discuss proprietary portfolio and client

performance as well as any significant market events that could impact the portfolio. The CIO use these insights to guide the overall investment strategy(Hillery, J, et al, 2023).

The Portfolio Manager will use XYZ's AI tools and reports generated to optimize the firm's investment portfolios based on the strategy set by but discussed with, the CIO. The Portfolio Management team will adjust asset allocations of the proprietary and client portfolios to maximize returns and minimize risk. The traders will use AI-powered trading systems to execute trades based on the optimized portfolios. They will monitor the systems throughout the day to ensure that are executing trades correctly (McKinsey, 2021; CFA Institute, 2021).

Figure 15 – XYZ Investment Management Firm Morning Activities

Generally, in the afternoon, the CIO dives deep into research papers, articles and data analytics to identify new and market emerging trends as it pertains to investment management (Hillery, J, et al, 2023; May, T., 2023).

The Quantitative Researcher will use AI algorithms to analyse financial data and identify investment opportunities The Quant team will share their findings with the CIO and portfolio manager. The CRM and CR Associates will use AI chatbots to manage routine client inquiries. They will also use AI tools to analyse client data and provide personalized investment advice. The IT Manager and ICT specialists ensure that the firm's AI systems are running smoothly. They troubleshoot any technical issues and implement updates as needed (McKinsey, 2021; CFA Institute, 2021).

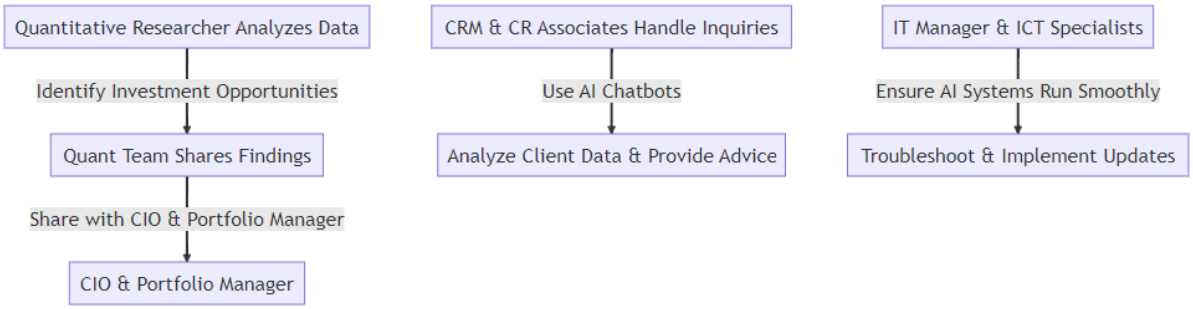


Figure 16 - XYZ Investment Management Firm Afternoon Activities

When evening arrives the Data Scientist will use machine learning algorithms to improve the firm's AI systems. The team will feed the systems new data, tweak their algorithms, and test their performance. When the markets close the quantitative analyst will use AI to analyze the day's trading data. The team will generate reports on the firm's and clients' investment performance and share these reports with the CIO and Portfolio Manager. The Legal and Compliance Officer will use XYZ's AI systems to ensure the firm remains compliant with all relevant financial regulations. The Officer will review AI generated compliance reports and address any issues (McKinsey, 2021; CFA Institute, 2021).

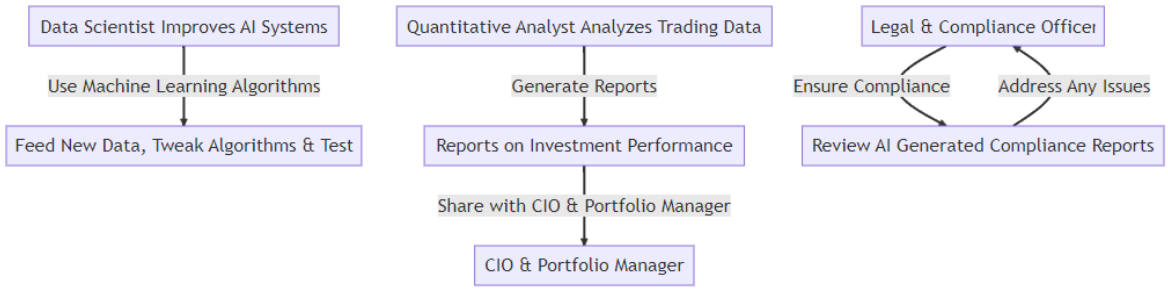


Figure 17 - XYZ Investment Management Firm Evening Activities

It should be noted that throughout the day, the XYZ team works alongside AI systems. They use the insights generated by the AI to make strategic decisions, interact with clients, and manage the firm's operations. They will also monitor the AI systems to ensure that are working correctly and ethically. Moreover, to further improve these systems, The AI will be provided with ethical guidelines and a code of conduct. These will include audits and attestations for the team.

6.5. Opportunities and Challenges of Artificial Intelligence in Investment Management for Trinidad and Tobago

As illustrated in the fictional firm above, the potential of AI to enhance decision-making, improve efficiency, manage risks, and predict market trends is immense. However, the journey towards AI integration is not without hurdles. Some of these hurdles range from data quality to finding the best candidates to assist with the AI integration. This is indeed a notable challenge specific to Trinidad and Tobago. Investment professionals will need to develop skills to implement and manage AI systems. This gap can hinder the effective utilization of AI in investment management specifically and finance generally. Despite these challenges, the potential benefits of AI make it a compelling proposition for the investment industry and overall financial sector in Trinidad and Tobago as well as the wider Caribbean Community.

6.6. Opportunities of Integrating AI in Investment Management

- Enhanced Decision-Making: AI algorithms can analyze vast amounts of data and generate insights that aid in informed decision-making. This leads to improved accuracy and efficiency in identifying investment opportunities and managing portfolios (OECD, 2021).
- Automation and Efficiency: Various tasks such as data collection, analysis, and portfolio rebalancing could be automated, saving time and reducing human error. It allows investment professionals to focus on higher-value activities such as strategy development and client relationships (OECD, 2021).
- Improved Risk Management: AI algorithms can assess risks in real-time, analyze complex relationships, and identify potential risks or anomalies more effectively than traditional methods. This helps in better risk assessment, portfolio diversification, and mitigation of potential losses (OECD, 2021).
- Enhanced Predictive Capabilities: With machine learning and predictive analytics, AI can forecast market trends, identify patterns, and make predictions about future market movements. This assists in generating more accurate investment strategies and improving portfolio performance (OECD, 2021).
- Fraud Detection and Security: AI systems can detect fraudulent activities, such as unauthorized transactions or suspicious patterns, more efficiently than manual methods. It helps financial institutions in fraud prevention and maintaining security. Fraud detection and security through AI will involve a multi-step process that

leverages machine learning algorithms, data analytics, and real-time monitoring. (OECD, 2021).

6.7. Challenges of Integrating AI in Investment Management

- Data Quality and Reliability: AI heavily relies on quality data for accurate analysis and predictions. Inaccurate or biased data can lead to flawed results and potentially incorrect investment decisions. Ensuring data quality and reliability is a crucial challenge (GOV.UK, 2021; CFA Institute, 2021).
- Lack of Interpretability and Transparency: The complexity of AI algorithms makes it difficult to understand how they arrive at specific decisions. Lack of transparency can lead to distrust, especially if investors cannot comprehend the reasoning behind AI-generated recommendations (CFA Institute, 2021).
- Cyber Attacks: Cyber attackers can leverage AI to craft advanced threats, and the heavy reliance on data would make financial and investment firms a prime target for data manipulation attacks. The inherent lack of transparency in many AI models complicates detection efforts, and the automation of decisions by AI can lead to substantial financial harm if compromised (IMF, 2021).
- Overreliance and Technical Limitations: Overreliance on AI systems without human oversight can be risky. Technical failures or limitations in AI algorithms can lead to financial losses. Human expertise is still valuable in interpreting AI-generated insights and making final decisions (CFA Institute, 2021).
- Regulatory and Ethical Challenges: The use of AI in investment management and finance raises ethical concerns regarding privacy, fairness, and accountability. Regulatory frameworks need to keep pace with technological advancements to address potential risks and ensure compliance (European Parliament, 2021).
- Market Instability and Black Swan Events: AI algorithms may struggle to adapt to unprecedented events or sudden market changes that fall outside the scope of historical data. Extra caution is necessary to account for unforeseen circumstances and the limitations of AI in extreme market conditions (Investopedia, 2021).
- Lack of Human Capital: The development, implementation and management of AI systems require a workforce with specialized skills in areas such as data science, machine learning and AI programming. In Trinidad and Tobago, there may be a shortage of such skilled professionals. This lack of human capital can hinder the effective utilization of AI technologies, as there may not be enough qualified individuals to handle the complexities AI systems, troubleshoot issues, or interpret

AI-generated insights. Furthermore, the lack of AI literacy among the broader workforce and leadership can also pose challenges in terms of understanding the potential benefits and limitations of AI (Ministry of Planning and Development, Trinidad and Tobago, 2022).

Overall, while AI offers significant advantages in investment management and finance, there are challenges that needs to be addressed to mitigate risks and ensure responsible utilization of AI technologies. Balancing the benefits of automation and data-driven insights with human expertise and ethical considerations is crucial for successful implementation.

6.8. Mitigating the Challenges of Integrating AI in Investment Management

Mitigating the challenges of integrating AI in investment management involves strategic planning, investment in human capital, and adherence to ethical and regulatory standards.

Investment firms such as XYZ can invest in data management systems and practices that ensure the accuracy, consistency, and reliability of data. This includes data cleaning, validation, and standardization processes. There are also data auditing tools available that firms can use to detect and correct errors in the data. When it comes to enhancing interpretability and transparency, firms can use explainable AI (XAI) techniques to provide insights into how the algorithms make decisions. This can help build trust among investors and other stakeholders. Firms should also be transparent about their use of AI, including the data, they use, the algorithms they employ, and the decisions made by the AI (OECD, 2021).

Additionally, when using AI, firms should stay updated on the latest regulatory developments related to AI and ensure that their AI systems comply with these regulations. They should also adhere to ethical standards, such as respecting privacy, ensuring fairness, and being accountable for AI decisions (Bank for International Settlements, 2021).

Indeed, AI would not end market instability and black swan events. Thus, firms like XYZ should continue to use stress testing and scenario analysis to prepare for extreme market conditions. They should also have contingency plans in place in case of AI failures during these events (Bank for International Settlements, 2021).

To address the lack of human capital, firms can invest in training and development programs to upskill their existing workforce. They can also collaborate with educational institutions to develop talent pipelines. In the long term, promoting AI literacy can help build a workforce that is equipped to work with AI (UKRI, 2023).

By mitigating some of the challenges, investment firms can effectively integrate AI into their operations and reap the benefits of this powerful technology.

6.9. The AI Revolution of Investment Management in Trinidad and Tobago

The integration of Artificial Intelligence in the investment management industry and financial sector, as illustrated by the fictional firm XYZ in Trinidad and Tobago, has the potential to revolutionize the industry. The use of AI can enhance decision making, improve efficiency, and manage risks more effectively. However, the journey towards successful AI integration is not without its challenges. These include ensuring data quality and reliability, maintaining transparency, avoiding overreliance on AI systems, addressing regulatory and ethical concerns, managing market instability and black swan events, and overcoming the lack of human capital.

7. CONCLUSION

It was 375 BC when Greek philosopher Plato released his text 'Republic', bringing us the phrase “necessity is the mother of all invention”. The technological and industrial revolutions experienced globally over the centuries reflect the world’s needs being realized and mankind finding a way to accomplish not just what is deemed necessary but also extraordinary feats of development and progress.

The Digital Revolution which we are a part of is one of tremendous significance to mankind. AI, broadly described as the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings is a key turning point for future generations and is poised to play a pivotal role in the future. AI makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.

The incorporation of Artificial Intelligence (AI), into the investment management sector in the English-speaking Caribbean will represent a significant change to the status quo.

The development of AI from machines to complex forms, such as limited memory systems and hypothetical self-aware machines offers the potential for improved decision making, personalized experiences and the development of groundbreaking trading strategies.

The financial industry, inspired by pioneers like Alan Turing, has embraced AI to enhance customer engagement manage risks effectively and ensure compliance. The adoption of AI in areas like trading underscores its transformative capabilities.

Beyond being an upgrade, the integration of AI redefines financial decision making. While debates continue regarding a revolution brought about by AIs influence on sectors, there is no denying its profound impact on fostering an intelligent and interconnected financial ecosystem.

The English-speaking Caribbean stands at the threshold of an era in investment that combines expertise with cutting edge technology. By harnessing the potential of AI financial services can be elevated to heights while contributing to global innovation. As we navigate through this evolving landscape with vigilance and adaptability guided by considerations, we can ensure that our transformation benefits society.

When looking at the development of AI, in investments we can see that there is a change on the horizon for investment management. Our research has delved into the possibilities and obstacles of AI uncovering a narrative specifically within the financial sector.

Navigating AI-powered investment in the Caribbean, is a journey of opportunity and challenge. The fusion of human expertise with AI potential heralds a new era of financial innovation. Embracing AI with prudence and ethical considerations will guide our transformation toward a reinvented investment landscape.

REFERENCES

AB Europe-Americas (n.d.). *AI Helps Create Financial Statements* [online]. Available from: https://abmagazine.accaglobal.com/global/articles/2023/specials/big-tech-special-edition-april-2023/ai-helps-create-financial-statements.html [accessed 24 July 2023].

Apiway (n.d.). *Top 5 Use Cases of NLP in Finance* [online]. Available from: https://apiway.ai/community/articles/821-top-5-use-cases-of-nlp-in-finance [accessed 27 July 2023].

Ashta, A. and Herrmann, H. (2021). Artificial intelligence and fintech: An overview of opportunities and risks for banking, investments, and microfinance. Strategic Change, Volume 30, pp. 211-222.

Aurum (2023). *Quant Deep Dive - August 2022* [online]. Available from: https://www.aurum.com/hedge-fund-data/hedge-fund-industry-deep-dive/quant-deep-dive-aug-22/#:~:text=Performance,master%20strategy%20was%20down%202.1%25. [accessed 07 August 2023].

Bachinskiy, A. (2019). *The growing impact of AI in financial services: Six examples* [online]. Available from: https://towardsdatascience.com/the-growing-impact-of-ai-in-financial-services-six-examples-da386c0301b2 [accessed 25 July 2023].

Bank for International Settlements (2021). Humans Keeping AI In Check – Emerging Regulatory Expectations In The Financial Sector [online]. Available from: https://www.bis.org/fsi/publ/insights35.htm [accessed 30 July 2023].

Bansal, S. (2019) *Explanation of Connectionist Temporal Classification* [online] Available from: https://sid2697.github.io/Blog_Sid/algorithm/2019/10/19/CTC-Loss.html [accessed 16 July 2023].

Bartram, S. M., Branke, J. and Motahari, M., 2020. *Research Foundation Literature Review - Artificial Intelligence in Asset Management*. 1st ed. Charlottesville, VA: CFA Institute Research Foundation [online] Available from: https://www.cfainstitute.org/-/media/documents/book/rf-lit-review/2020/rflr-artificial-intelligence-in-asset-management.ashx [accessed 24 August 2023]

BCG Global (n.d.) *Generative AI* [online]. Available from: https://www.bcg.com/capabilities/artificial-intelligence/generative-ai [accessed 06 August 2023].

Bellamacina, L. and Attah, E. (2022). *5 Ways AI is Shaping the Future of Investment Research* [online]. Available from: https://www.bloomberg.com/professional/blog/5-ways-ai-is-shaping-the-future-of-investment-research-2 [accessed 27 July 2023].

Bloomberg Professional Services (2019). *What's an "Algo Wheel?" And why should you care?* [online]. Available from: https://www.bloomberg.com/professional/blog/whats-algo-wheel-care [accessed 16 August 2023].

Bloomberg Professional Services (2023). *Introducing BloombergGPT, Bloomberg's 50-billion parameter large language model, purpose-built from scratch for finance* [online]. Available from: https://www.bloomberg.com/company/press/bloomberggpt-50-billion-parameter-llm-tuned-finance/ [accessed 31 July 2023].

Bothra, N. (2023). *How quant investing is helping investors beat the market* (no date a) *Forbes India*. Available from: https://www.forbesindia.com/article/take-one-big-story-of-the-day/how-quant-investing-is-helping-investors-beat-the-market/84979/1#:~:text=In%20fact%2C%20the%20Quant%20Value,43.5%20percent%20(see%20table) [accessed on 22 August 2023].

Brown, A. (2023). *Dreams of Replacing Humans in Finance May Come True* [online]. Available from: https://www.bloomberg.com/opinion/articles/2023-04-21/dreams-of-ai-replacing-humans-in-finance-may-come-true [accessed 27 July 2023].

Brown, S. (2021) *Machine learning, explained* [online]. Available from: https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained [accessed 04 August 2023].

Buchanan, B. (2019). *Artificial intelligence in finance* [online]. Available from: https://www.turing.ac.uk/news/publications/artificial-intelligence-finance [accessed 27 July 2023].

Burns, J. (2022). *The Case For Quant In A Rising Dispersion Environment* [online]. Available from: https://icapital.com/insights/hedge-funds/the-case-for-quant-in-a-rising-dispersion-environment/ [accessed on 22 August 2023].

Burrows, R. (2019) *Will AI soon be preparing your annual reports?* [online]. Available from: https://www.lexology.com/library/detail.aspx?g=d21dfa52-1224-44dd-bda9-6c3eb4fb7f09 [accessed 24 July 2023].

Business Insider (2022). *Here Are 9 Fascinating Facts To Know About Blackrock, The World's Largest Asset Manager* [online]. Available from: https://www.businessinsider.com/what-to-know-about-blackrock-larry-fink-biden-cabinet-facts-2020-12 [accessed 31 July 2023].

Cao, L. (2023). *Handbook of Artificial Intelligence and Big Data Applications in Investments*. Charlottesville, Virginia: CFA Institute Research Foundation.

Capponi, A., Olafsson, S. and Zariphopoulou, T. (2019). Personalized Robo-Advising: Enhancing Investment through Client Interaction [online]. Available from: http://arxiv.org/pdf/1911.01391v2 [accessed 30 July 2023]

CFA Institute (2020). *Artificial Intelligence In Asset Management* [online]. Available from: https://www.cfainstitute.org/-/media/documents/book/rf-lit-review/2020/rflr-artificial-intelligence-in-asset-management.ashx [accessed 30 July 2023]

CFA Institute (2021). *Machine Learning and Data Science Applications in Investments* [online]. Available from: https://www.cfainstitute.org/-/media/documents/article/rf-brief/ai-and-big-data-in-investments-Part-I.pdf [accessed 30 July 2023]

Chandra, A. (2020). *Does Quant Fund performance outperform human-managed?* [online]. Available from: https://www.toptal.com/finance/stock-market-experts/quant-fund-performance [accessed on 22 August 2023].

Chen, G., Chen, Y. and Fushimi, T. (2017). Application of Deep Learning to Algorithmic Trading. Stanford University Computer Science , Volume 229.

CNN Money (2018). *AI Companies Spot A Business Opportunity In Space* [online]. Available from: https://money.cnn.com/2018/04/06/technology/business/geospatial-analytics-satellite/index.html [accessed 8 August 2023].

Conlon, T., Cotter, J. and Kynigakis, I. (2021). Machine Learning and Factor-Based Portfolio Optimization [online]. Available from: http://arxiv.org/pdf/2107.13866v1 [accessed 30 July 2023]

Counts, L. (2019). *How Hedge Funds Use Satellite Images To Beat Wall Street—And Main Street* [online]. Available from: https://newsroom.haas.berkeley.edu/how-hedge-funds-use-satellite-images-to-beat-wall-street-and-main-street/ [accessed 8 August 2023].

Coursera. (2023) *4 Types of AI: Getting to Know Artificial Intelligence* [online]. Available from: https://www.coursera.org/articles/types-of-ai [accessed 03 August 2023].

Dahlberg, J. (2022). *Data extraction from SEC filings (10-KS) with snorkel flow* [online]. Available from: https://snorkel.ai/data-extraction-sec-filings-10-ks/ [accessed 25 July 2023].

Data Science Central (2022). *Replacing Traders With Algorithms: Success Stories of Real Funds* [online]. Available from: https://www.datasciencecentral.com/replacing-traders-with-algorithms-success-stories-of-real-funds/ [accessed 31 July 2023].

Davenport, T. H. and Bean, T. (2021). AI IN ACTION: The Pursuit of AI-Driven Wealth Management. [online] Available from: https://sloanreview.mit.edu/article/the-pursuit-of-ai-driven-wealth-management [accessed 27 July 2023].

DeChesare, B. (n.d.). *The Full Guide to Quant Funds: Careers, Salaries, Recruiting, Exits, and More* [online]. Available from: https://mergersandinquisitions.com/quant-funds/#:~:text=The%20Top%20Quant%20Funds&text=Some%20of%20the%20top%20funds,Group%2C%20Millennium%2C%20and%20Bridgewater [accessed on 22 August 2023].

Delera, M. and Lavopa, A (2021) *What is the Fourth Industrial Revolution?* [online]. Available from: https://iap.unido.org/articles/what-fourth-industrial-revolution [accessed 02 August 2023].

Deloitte. (2023) *Artificial Intelligence: The Next Frontier in Investment Management* [online]. Available from: https://www.deloitte.com/global/en/Industries/financial-services/perspectives/ai-next-frontier-in-investment-management.html [accessed 06 August 2023].

Dilmegani, C. (2023). *10+ generative AI finance use cases in 2023* [online]. Available from: https://research.aimultiple.com/generative-ai-finance/ [accessed 24 July 2023].

Dunn, B. (2021). *Will Artificial Intelligence Take Over Quantitative Investing?* [online] Available from: https://www.eastspring.com/docs/librariesprovider6/our-perspectives/market-insights/2021/will-ai-take-over-quantitative-investing.pdf [accessed on 22 August 2023].

Elliot, J. (2023) *How Edge AI is Fueling Industry 4.0 Outcomes* [online]. Available from: https://www.forbes.com/sites/forbestechcouncil/2023/06/20/how-edge-ai-is-fueling-industry-40-outcomes/?sh=89b7b8078d03 [accessed 02 August 2023].

Engdahl, S. (2008) *Create a dashboard with SEC text for financial NLP in Amazon SageMaker JumpStart* [online]. Available from: https://aws.amazon.com/blogs/machine-learning/create-a-dashboard-with-sec-text-for-financial-nlp-in-amazon-sagemaker-jumpstart/ [accessed 25 July 2023].

Euroconsult (2021). *New Satellite Market Forecast Anticipates 1,700 Satellites To Be Launched On Average Per Year By 2030 As New Entrants And Incumbents Increase Their Investment In Space* [online]. Available from: https://www.euroconsult-ec.com/press-release/new-satellite-market-forecast-anticipates-1700-satellites-to-be-launched-on-average-per-year-by-2030-as-new-entrants-and-incumbents-increase-their-investment-in-space [accessed 8 August 2023].

European Parliament (2021). Ethics guidelines for trustworthy AI. Available from: Link [accessed 30 July 2023].

Faggella, D. (2020) *AI In Banking - An Analysis Of America's 7 Top Banks* [online]. Available from: https://emerj.com/ai-sector-overviews/ai-in-banking-analysis/ [accessed 27 July 2023].

FinText (n.d.). *How Finance Uses Natural Language Processing* [online]. Available from: https://www.fintext.io/case-studies/benchmarking/how-finance-uses-natural-language-processing/ [accessed 27 July 2023].

Foote, K.D. (2022) *A Brief History of Artificial Intelligence* [online]. Available from: https://www.dataversity.net/brief-history-artificial-intelligence/ [accessed 16 July 2023].

Forbes (2020). *The Future Of Work Now: Morgan Stanley's Financial Advisors And The Next Best Action System* [online]. Available from: https://www.forbes.com/sites/tomdavenport/2020/05/16/the-future-of-work-now-morgan-stanleys-financial-advisors-and-the-next-best-offer-system/?sh=2f1232a27027 [accessed 27 07 2023].

Forbes Advisor (2022). *Top-10 Robo-Advisors By Assets Under Management* [online]. Available from: https://www.forbes.com/advisor/investing/top-robo-advisors-by-aum/ [accessed 31 July 2023].

Forbes (2023) *Artificial intelligence applications in investing* [online]. Available from: https://www.forbes.com/sites/qai/2023/02/24/artificial-intelligence-applications-in-investing/?sh=40ce4c25e216 [accessed 02 August 2023].

Forbes (2023). *Vanguard Digital Advisor Review 2023* [online]. Available from: https://www.forbes.com/advisor/investing/vanguard-digital-advisor-review/ [accessed 27 July 2023].

Gaskell, A. (2023) *What can past technological revolutions tell us about today?* [online]. Available from: https://www.forbes.com/sites/adigaskell/2023/02/04/what-can-past-technological-revolutions-tell-us-about-today/?sh=3e12b3207442 [accessed 31 July 2023].

GOV.UK (2021). AI Barometer Report [online]. Available from: Link [accessed 30 July 2023].

Hentzen, J. K., Hoffmann, A., Dolan, R. and Pala, E. (2022). *Artificial intelligence in customer-facing financial services: a systematic literature review and agenda for future research*. International Journal of Bank Marketing, 40(6), pp. 1299-1336.

Hillery, J. and Lewis, N. (2023). *What CIOs Need to Know About Deploying AI*. [online] Available from: https://www.gartner.com/en/articles/what-cios-need-to-know-about-deploying-ai [accessed 6 September 2023].Huang, G., Zhou, X. and Song, Q. (2020). Deep reinforcement learning for portfolio management. Available from: http://arxiv.org/pdf/2012.13773v7 [accessed 30 July 2023]

HubSpot (2023). *The State of AI in Customer Service [New Data]* [online]. Available from: https://blog.hubspot.com/service/state-of-ai-in-service [accessed 31 July 2023].

Hunter, T. (2023) *3 Things Everyone's Getting Wrong About AI* [online]. Available from: https://www.washingtonpost.com/technology/2023/03/22/ai-red-flags-misinformation/ [accessed 16 July 2023].

IBM. (n.d.) *What is Artificial Intelligence (AI)?* Available from: https://www.ibm.com/topics/artificial-intelligence [accessed 02 August 2023].

IDB Invest (2023) *The Great Tech Revolution: Artificial General Intelligence & Multilateral Development Banks* [online]. Available from: https://www.idbinvest.org/en/blog/digital-economy/great-tech-revolution-artificial-general-intelligence-multilateral-development [accessed 03 August 2023].

IMF (2021). *Powering the Digital Economy: Opportunities and Risks of Artificial Intelligence in Finance* [online]. Available from: https://www.elibrary.imf.org/view/journals/087/2021/024/article-A001-en.xml [accessed 30 July 2023]

Impact Lab (2017). *How Satellites, Drones, and Planes, are Making Hedge Funds Money.* [online]
Available from: https://www.impactlab.com/2017/10/18/how-satellites-drones-and-planes-are-making-hedge-funds-money [accessed 8 August 2028].

Institute of Entrepreneurship Development. (2023) *The 4 Industrial Revolutions* [online]. Available from: https://ied.eu/project-updates/the-4-industrial-revolutions [accessed 02 August 2023].

Intel (n.d.). *AI in financial services: Use cases and applications* [online]. Available from: https://www.intel.com/content/www/us/en/financial-services-it/fintech/ai-in-financial-services.html [accessed 25 July 2023].

Investopedia (2021). Basics of Algorithmic Trading: Concepts and Examples [online]. Available from: https://www.investopedia.com/articles/active-trading/101014/basics-algorithmic-trading-concepts-and-examples.asp [accessed 30 July 2023]

Jimenez, J., Sherlock, H., Juarez, L. et. al. (2023) *How to improve your finance operation's efficiency with Generative AI* [online]. Available from: https://www.ibm.com/blog/how-to-improve-your-finance-operations-efficiency-with-generative-ai/ [accessed 29 July 2023].

Joshi, N. (2022) *7 Types of Artificial Intelligence* [online]. Available from: https://www.forbes.com/sites/cognitiveworld/2019/06/19/7-types-of-artificial-intelligence/?sh=39e355d2233e [accessed 02 August 2023].

KlearStack (2023). *AI Annual reports OCR - financial data extraction* [online]. Available from: https://www.klearstack.com/annual-reports-ocr/ [accessed 25 July 2023].

KPMG, 2022. Staying One Step Ahead - BlackRock's Aladdin. Frontiers in Finance, May, Issue #64, pp. 14-17.

Kruse, L., Wunderlich, N. & Roman, B., 2019. Artificial Intelligence for the Financial Services Industry: What Challenges Organizations to Succeed. Maui, Hawaii, Conference: Proceedings of the 52nd Hawaii International Conference on System Sciences (HICSS 2019).

Lim, M. (2018). *History of AI Winters* [online]. Available from: https://www.actuaries.digital/2018/09/05/history-of-ai-winters [accessed 22 August 2023].

Lorè, F., Basile, P., Appice, A., et. al. (2023). An AI Framework to Support Decisions on GDPR Compliance. Available from: https://link.springer.com/content/pdf/10.1007/s10844-023-00782-4.pdf [accessed 30 July 2023].

Marcos, D. (2023). *Trade smarter with the LPA Algo Wheel* [online]. Available from: https://www.l-p-a.com/2023/01/16/the-lpa-algo-wheel/ [accessed 16 August 2023].

Maslowska, S. (2023) *Automating Financial Reports with AI for Efficiency and Accuracy* [online]. Available from: https://www.netguru.com/blog/automating-financial-reports-ai [accessed 01 August 2023].

May, T. (2023). *Your AI Journey: Destined for the Ditch?* [online] Available from: https://www.cio.com/article/649914/your-ai-journey-destined-for-the-ditch.html [accessed 6 September 2023]

McCabe, C. (2023) *Asset and Wealth Management–Embracing AI and Consolidation to Win* [online]. Available from: https://www.forbes.com/sites/carriemccabe/2023/07/20/asset-and-wealth-management-embracing-ai-and-consolidation-to-win/?sh=78a8c5dd7f8f [accessed 04 August 2023].

McCarthy, J. (2007) *What is Artificial Intelligence* [online] Available from: https://www-formal.stanford.edu/jmc/whatisai.pdf [accessed 16 July 2023].

Medium.com (2023). *Genetic Algorithms in Trading: Using Evolutionary Computation to Optimize Trading Strategies* [online]. Available from: https://medium.com/@nomadworld/genetic-algorithms-in-trading-using-evolutionary-computation-to-optimize-trading-strategies-d7afac52d646 [accessed 16 August 2023].

McKinsey and Company (2021). *Driving impact at scale from automation and AI* [online]. Available from: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Driving%20impact%20at%20scale%20from%20automation%20and%20AI/Driving-impact-at-scale-from-automation-and-AI.ashx [accessed 30 July 2023]

Ministry of Planning and Development, Trinidad and Tobago (2022). *Labour skills assessment and policy recommendations for the ICT Platforms & Services Sub-Sector T&T* [online]. Available from: https://www.planning.gov.tt/content/labour-skills-assessment-ict-platforms-services-sub-sector-tt-2022 [accessed 30 July 2023]

Morgan Stanley (n.d.). *Quant strategies offer a bright spot* [online]. Available from: https://www.morganstanley.com/ideas/quantitative-investing-outperformance-2023#:~:text=Quantitative%20(or%20quant)%20investing%20uses,are%20grounded%20in%20historical%20data [accessed on 22 August 2023].

NVIDIA. (n.d.) *What is Generative AI?* [online] Available from: https://www.nvidia.com/en-us/glossary/data-science/generative-ai/ [accessed 06 August 2023].

OECD (2021). *Artificial Intelligence, Digital Technology and Advanced Production* [online]. Available from: https://www.oecd-ilibrary.org/sites/629af843-en/index.html?itemId=/content/component/629af843-en [accessed 30 July 2023].

OECD (2021). *Artificial Intelligence, Machine Learning and Big Data in Finance: Opportunities, Challenges, and Implications for Policy Makers* [online]. Available from: https://www.oecd.org/finance/financial-markets/Artificial-intelligence-machine-learning-big-data-in-finance.pdf [accessed 30 July 2023].

O'Connell, B. (2023) *7 Top Investment Firms Using AI for Asset Management* [online] Available from: https://money.usnews.com/investing/articles/7-top-investment-firms-using-ai-for-asset-management [accessed 28 July 2023].

Oracle. (n.d.) *What is machine learning?* [online] Available from: https://www.oracle.com/hk/artificial-intelligence/machine-learning/what-is-machine-learning/ [accessed 02 August 2023].

Orbital Insight (2023). *Understand What Is Happening On And To The Earth.* [online] Available from: https://s3.us-west-1.amazonaws.com/orbital-us/doc/Orbital-Insight-Overview-v5.pdf [accessed 8 August 2023].

Pozen, R. and Ruane, J. (2019) *What Machine Learning Will Mean for Asset Managers* [online]. Available from: https://hbr.org/2019/12/what-machine-learning-will-mean-for-asset-managers [accessed 06 August 2023].

PricewaterhouseCoopers (2023) *Asset and Wealth Management Revolution 2023: The New Context* [online]. Available from: https://www.pwc.com/gx/en/industries/financial-services/asset-management/publications/asset-and-wealth-management-revolution-2023.html [accessed 06 August 2023].

Q.ai (n.d.) *A Forbes Company: Powering A Personal Wealth Movement* [online]. Available from: https://start.tryq.ai/ [accessed 02 August 2023].

Rodrigue, E. (2023) *4 Types of Artificial Intelligence & What Marketers are Using Most (Research)* [online]. Available from: https://blog.hubspot.com/marketing/types-of-ai [accessed 04 August 2023].

SAS. (n.d.) *Artificial Intelligence (AI): What it is and why it matters* [online]. Available from: https://www.sas.com/en_us/insights/analytics/what-is-artificial-

intelligence.html#:~:text=Artificial%20intelligence%20(AI)%20makes%20it,learning%20and%20natural%20language%20processing [accessed 02 August 2023].

Schmidt, M. (2023) *Using quantitative investment strategies* [online]. Available from: https://www.investopedia.com/articles/trading/09/quant-strategies.asp [accessed on 22 August 2023].

Schroer, A. (n.d.). *29 Examples Of AI In Finance* [online]. Available from: https://builtin.com/artificial-intelligence/ai-finance-banking-applications-companies [accessed 24 July 2023].

Statista, 2023. Rise of the Robo-Advisors [online]. Available from: https://www.statista.com/chart/30114/robo-abdvisor-assets-under-management-and-revenue/ [accessed 31 July 2023].

Street of walls (n.d.). *What is a Quantitative Hedge Fund*. Available from: https://www.streetofwalls.com/finance-training-courses/quantitative-hedge-fund-training/what-is-a-quant-hedge-fund/#:~:text=Quantitative%20Hedge%20Funds%20development%20complex,returns%20(for%20short%20investments) [accessed on 22 August 2023].

Tewari, G. (2022) *Recent Advancements in Artificial Intelligence* [online]. Available from: https://www.forbes.com/sites/forbesbusinesscouncil/2022/10/07/recent-advancements-in-artificial-intelligence/?sh=7f76f5c27fa5 [accessed 16 July 2023].

The Atlantic Magazine (2019). *Stock Picks From Space* [online] Available from: https://www.theatlantic.com/magazine/archive/2019/05/stock-value-satellite-images-investing/586009/ [accessed 8 August 2023].

The U.S. Geological Survey (2023). *Chart of Commercial, Government-Civil Satellites Launched.* [online] Available from: https://www.usgs.gov/media/images/chart-commercial-government-civil-satellites-launched [accessed 8 August 2023].

Tyagi, S. (2022). *Analyzing Machine Learning Models for Credit Scoring with Explainable AI and Optimizing Investment Decisions* [online]. Available from: http://arxiv.org/pdf/2209.09362v1 [accessed 30 July 2023]

UK Research and Innovation (2023). *Attracting And Training Talent for the AI-Enabled Economy* [online]. Available from: https://www.ukri.org/blog/attracting-and-training-talent-for-the-ai-enabled-economy/ [accessed 30 July 2023]

University of San Diego Online Degrees (n.d.). *Artificial Intelligence in Finance [15 examples]* [online]. Available from: https://onlinedegrees.sandiego.edu/artificial-intelligence-finance/ [accessed 27 July 2023].

Van de Wetering, S. (2023) *AI In Investment Management: What to Know and How to Benefit* [online]. Available from: https://www.empaxis.com/blog/ai-in-investment-management [accessed 04 August 2023].

West, D.M and Allen J.R. (2018) *What is Artificial Intelligence?* [online]. Available from: https://www.brookings.edu/articles/what-is-artificial-intelligence [accessed 26 July 2023].

Wu, S., Ozan, I., Lu, S., et al. (2023). *BloombergGPT: A Large Language Model for Finance* [online]. Available from: https://arxiv.org/pdf/2303.17564.pdf [accessed 31 July 2023].