# REVOLUTIONIZING ASSET MANAGMENT: THE IMPACT OF FINTECH AND ALGORITHMIC INNOVATIONS WITH A FOCUS ON AUDERE INVEST IN SHAPING MODERN FINANCIAL STRATEGIES

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ABSTRACT

This thesis offers an in-depth analysis of how financial technology and algorithmic advancements are revolutionizing financial management. It commences with an expansive introduction to FinTech, tracing its evolution from inception to its current state and forecasting its potential future influence on the financial sector. This foundational chapter delves into the transformative role of FinTech, setting the stage for a deeper understanding of its disruptive impact across financial practices.

In the second chapter, the focus shifts to the disruptive impact of FinTech on traditional banking. It critically examines how innovations such as blockchain, artificial intelligence (AI), algorithmic trading, and high-frequency trading are redefining cost structures and enhancing operational efficiencies. This section highlights the pivotal challenges these technologies pose to established financial norms and the opportunities they create for reengineering the banking landscape. Further exploration reveals how technological integration is transforming asset management, enhancing capabilities through advanced analytical tools and improving the responsiveness of financial strategies to market changes.

Building on these discussions, the narrative then addresses the emergent dynamics of low-frequency trading (LFT), which bridges traditional asset management with modern algorithmic innovation. This addition underscores how LFT leverages technological advancements to maintain alignment with long-standing financial principles, offering a methodical approach to investment that contrasts with the rapid, speculative strategies seen in high-frequency trading.

Chapter III of this thesis meticulously examines the transformative shift in investment paradigms driven by technological advancements, as evidenced by significant insights from recent financial reports. The chapter begins with an exploration of the transition from traditional discretionary management to structured, technology-enhanced non-discretionary methods. This shift highlights how passive investment strategies have gained prominence, driven by their cost-efficiency and robust performance during market volatilities. The SPIVA (S&P Dow Jones Indices Versus Active) U.S. Year-End 2022 report reveals that a staggering 93% of actively managed funds failed to outperform their benchmarks over a 15-year period, underscoring the declining edge of active sector fund management. Similarly, the Morningstar Active/Passive Barometer indicates that only 24% of active funds outperformed their passive counterparts over the last decade, illustrating the growing dominance of passive strategies and the ongoing demonstration of market inefficiencies through crises.

The narrative then delves into the proliferation of Exchange-Traded Funds (ETFs) and their significant impact on the investment landscape. ETFs have been instrumental in exposing the limitations of active management by offering more transparent, cost-effective, and efficient investment alternatives. From simple index trackers to sophisticated vehicles like smart beta and factor ETFs, these funds have evolved to integrate elements of both passive and active management to achieve specific investment goals. They play a pivotal role in modern investment strategies and are rising in a transforming global market.

Further, the chapter explores the profound impact of algorithmic trading and data-driven decision making on market dynamics. Advancements in data analysis and algorithmic approaches have revolutionized trading and investment strategies, making markets more efficient and providing investors with tools for risk management and performance enhancement. Additionally, the text addresses common misconceptions about artificial intelligence in finance, offering a grounded perspective on the actual capabilities and limitations of AI technologies. It aims to demystify AI, highlighting its supportive role rather than supplanting human decision-making in financial contexts.

The discussion also covers the psychological and cultural dimensions of financial technology, addressing the barriers to adopting new technologies within finance. As these technologies continue to demonstrate their value and robustness, the finance sector is expected to undergo a significant transformation towards more efficient, transparent, and automated systems, reshaping how investments are managed and decisions are made. The integration of these technological innovations is inevitable as the industry adapts to remain competitive and relevant in a rapidly evolving global market.

The fourth chapter delves into the complexities of regulation and oversight in algorithmic trading. It methodically lays out the regulatory frameworks, the challenges in their implementation, and the mechanisms for ensuring compliance. It also offers prognostications on the future challenges and directions of these regulatory frameworks, aiming to strike a balance between fostering innovation and managing risk in rapidly evolving financial markets.

The thesis culminates focusing on a case study of Audere Invest SA, a leader in algorithm-driven investment solutions. The study delves into the synergy between the Audere team's expertise and their advanced financial strategies, highlighting the role of collaborative efforts in driving innovation. It examines the gAintrader model, emphasizing its use of sophisticated machine learning techniques to enhance financial prediction accuracy and streamline cluster analysis. This model represents a significant shift from traditional financial models by introducing revolutionary adaptability and predictive capabilities through strategic multi-frequency trading, customizable risk management, and a versatile platform capable of handling diverse asset classes.

The narrative then shifts to the technical and operational architecture that supports Audere's complex trading scenarios, alongside the foundational services that ensure compliance and robust client support. A critical analysis follows, demonstrating the practical effectiveness of Audere's algorithms through empirical evidence, showcasing their impact on market efficiency and asset management practices. The chapter concludes by discussing the broader adoption of algorithmic trading strategies among major financial institutions, exemplified by BNP Paribas's implementation of similar technologies, underscoring a trend towards technological integration within traditional financial

settings. This examination not only reflects technological advancements but also marks a fundamental shift in the approach to market participation and regulation in the financial sector.

Overall, this thesis comprehensively examines the transformative impact of FinTech and algorithmic innovations on the financial industry. It articulates how these technologies are reshaping asset management practices and driving the evolution of regulatory frameworks necessary for maintaining market integrity and stability. A key objective of this exploration is to establish a contextual foundation for the Audere case study. This case study not only illustrates the practical application of the theoretical concepts discussed but also highlights how advanced algorithmic strategies can be effectively implemented within an asset management firm, providing a real-world embodiment of the thesis's themes.

#### Acknowledgments

I extend my heartfelt gratitude to Audere Invest SA for their invaluable cooperation and support throughout my research. Their openness and readiness to provide insights and data have significantly enriched this thesis. The practical examples and real-world applications provided by Audere Invest have been instrumental in illustrating the transformative impact of algorithmic trading and FinTech innovations in asset management. I am particularly thankful to the team at Audere for their expertise and willingness to share their profound knowledge of the industry, which has greatly enhanced the depth and relevance of my study. Their contribution has not only facilitated a comprehensive exploration of advanced financial technologies but also highlighted the practical implications of these innovations in the current financial landscape.

Special thanks to Dr. Alberto Micalizzi, the ideator of the pioneering algorithm that has been central to this thesis. His insights and expertise have not only enriched this study but have also been instrumental in guiding my understanding of the intricate relationship between technology and finance. Alberto's profound knowledge and innovative approach have provided a foundational perspective that has deeply influenced my academic and professional outlook.

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#### I. GENERAL INTRODUCTION TO FINTECH

Fintech stands for Financial Technology and refers to all those financial solutions enabled by technology. The first appearance of the terminology can be seen referring to the "Financial

Services Technology Consortium", a project by Citigroup to improve technological efforts<sup>1</sup>.

Going deeper on the history of fintech, Douglas W. Arner, Janos Nathan Barberis and Ross P. Buckley distinguish four main eras of fintech<sup>2</sup>.

The first era defined as Fintech 1.0 corresponds according to the above mentioned text to the first age of financial globalization. A perfect picture of this link is provided by the major economist of the century, J.M Keynes who states that a man in London while sipping his tea, could by a mean of a telephone call, invest his wealth in any new enterprise in any quarter of the world<sup>3</sup>.

Fintech 2.0 instead lies between 1967 and 2008, this era started from the launch of the calculator and the ATM in 1967, continued with the establishment of the Clearing House Interbank Payments System and of the National Association of Securities Dealers Automated Quotations known as NASDAQ in the 70s and had its most important exploit with the world wide use of the world wide web which in 2005 gave life to the first direct banks without physical branches. This era of Fintech also brought the first questions about regulations as "An internet-based bank is faced with the same types of banking risk as its traditional counterparties. In some ways, the internet may heighten these risks. For example, the ability to transfer funds between different bank accounts may increase deposit volatility and could, in extreme situations, lead to "virtual bank runs". Banks will need to build this possibility into their liquidity management policies"<sup>4</sup>.

However, the FinTech 3.0 era has shown that financial services provision no longer solely rests with regulated financial institutions. The provision of financial services by non-banks may also mean there are no effective home regulators to act on the concerns of host regulators, and thus whether the provider is regulated or not may make little difference. This means that the last safeguard may come from consumer education and the distrust of placing funds with an off-shore non-bank.

Yet, even this last constraint has been undermined since 2007, when the brand image of banks and their perceived stability was shaken to the core. At this regard, a 2015 survey shows how Americans tend to trust technological firms more than they trust banks in handling their finances. For example, the level of trust Americans have in Citibank is 37%, whilst trust in Amazon and Google is 71% and 64% respectively<sup>5</sup>.

Fintech 3.0 starts in 2008, after the peak of the financial crisis when regulations like the Dodd – Frank Act and Basel III, imposing stringent capital requirements and increasingly compliance obligations have inadvertently restricted traditional banks while facilitating the rise of fintech firms. These conditions have enabled new actors to leverage technology in offering financial services, effectively democratizing access to financial resources and reshaping the industry, where "banking is necessary, banks are not"<sup>6</sup> or as more strongly, expressed by Bill gates, "banks are dinosaurs, we can bypass them"<sup>7</sup>.

8, 1999), http://www.bis.org/review/r991012c.pdf.

<sup>&</sup>lt;sup>1</sup> See Marc Hochstein, Fintech (the Word, That Is) Evolves, AMERICAN BANKER (Oct. 5, 2015),

http://www.americanbanker.com/bankthink/fintech-the-word-that-is-evolves-1077098-1.html.

<sup>&</sup>lt;sup>2</sup> Arner, Douglas W. and Barberis, Janos Nathan and Buckley, Ross P., The Evolution of Fintech: A New Post-Crisis Paradigm? (October 1, 2015). University of Hong Kong Faculty of Law Research Paper No. 2015/047, UNSW Law Research Paper No. 2016-62, Available at SSRN: https://ssrn.com/abstract=2676553 or http://dx.doi.org/10.2139/ssrn.2676553

<sup>&</sup>lt;sup>3</sup> John Maynard Keynes, The Economic Consequences of the Peace 10-12 (1920).

<sup>&</sup>lt;sup>4</sup> David Carse, Keynote: The regulatory framework of e-banking, HONG KONG MONETARY AUTHORITY 4 (Oct.

<sup>&</sup>lt;sup>5</sup> LET'S TALK PAYMENTS. (2015). Survey Shows Americans Trust Technology Firms More Than Banks and Retailers. Retrieved from http://letstalkpayments.com/survey-shows-americans-trust-technology-firms-more-than-banks-and-retailers/

<sup>&</sup>lt;sup>6</sup> By Richard Kovacevich see Bethany McLean, Is This Guy The Best Banker In America?, FORTUNE (Jul. 6, 1998), http://archive.fortune.com/magazines/fortune/fortune\_archive/1998/07/06/244842/index.htm

<sup>&</sup>lt;sup>7</sup> Bill Gates, Culture Club, NEWSWEEK (Jul. 10, 1994), http://www.newsweek.com/culture-club-189982.

The 3.0 is the first era where significant regulatory approaches to the fintech can be found, but this is also the era of some pioneering innovations particularly the one of the Blockchain technology and Open Banking.

Given a continuously rising importance, the evolution of fintech could not anymore account only for the markets in the west but had to widen its view to the east, particularly to China, giving life to that era referred to as Fintech 3.5.

In fact, the Chinese market is particularly propense to the fintech development as analysed by McKinsey in its report about digital innovation in China<sup>8</sup>. China with its 990 billion, has more internet users than combined European and US ones. Also, China is the biggest ecommerce market in the world leading in major digital metrics such as the mobile payments penetration percentage and retail ecommerce gross merchandise value.

Moreover, the evolution of FinTech in China is significantly driven by the digital ecosystems created by giants such as Baidu, Alibaba, and Tencent. These platforms have evolved beyond their initial functions to incorporate advanced digital payments and create massive, high-engagement user bases.

This innovation is supported by a regulatory framework that initially allowed a wide berth for experimentation, providing a fertile ground for FinTech to flourish before implementing more stringent controls once these platforms reached a considerable scale.

Africa and Asian Pacific region share similarities in terms of fintech economies as both have rapidly embraced mobile technologies enhancing financial inclusion by providing services to previously unbanked populations. For example, in Africa, the mobile money platform M-Pesa has significantly transformed financial access, especially in Kenya where in five years the payments made through the platform reached the 43% of the nation's GDP<sup>9</sup>. Both regions also face similar challenges, such as diverse regulatory environments and substantial rural populations lacking traditional banking services. In fact, according to KPMG 20% of African households don't have access to financial services<sup>10</sup>. However, these challenges present unique opportunities for FinTech solutions tailored to address specific local needs, driving investment and innovation in startups across both regions.

In fact, according to Briter Bridges<sup>11</sup>, 2021 financial technology companies capture the largest share of funding on the continent as 2/3 of all deals above 50 million Dollars are in fintech while above 100 million Dollars, 62% of total funding goes to fintech.

<sup>&</sup>lt;sup>8</sup> The Future of Digital Innovation in China: Megatrends Shaping One of the World's Fastest Evolving Digital Ecosystems. By Lambert Bu, Violet Chung, Nick Leung, Kevin Wei Wang, Bruce Xia, and Chenan Xia. https://www.mckinsey.com/featured-insights/china/the-future-of-digital-innovation-in-china-megatrends-shaping-one-of-the-worlds-fastest-evolving-digital-ecosystems?cid=eml-web

<sup>&</sup>lt;sup>9</sup> See Gabriella Mulligan, Can M-Pesa travel outside Kenya?, AFRICAN BUSINESS (Dec. 2, 2014),

http://africanbusinessmagazine.com/sectors/technology/can-m-pesa-travel-outside-kenya/.

<sup>&</sup>lt;sup>10</sup> See Financial Services in Africa, KPMG 4 (2013),

https://www.kpmg.com/Africa/en/IssuesAndInsights/ArticlesPublications/Documents/KPMG%20Financial%20Services%20i n%20Africa.pdf.

<sup>&</sup>lt;sup>11</sup> Africa investment report, Briter Bridges, 2021



This is analysed in the McKinsey & Company report on fintech in Africa<sup>12</sup> which highlights how in 2021 the sector received 54% of the continent's startup funding. Also, approximately 65% of the population remains either completely unbanked or underbanked, indicating a substantial market for financial services innovation. The COVID-19 pandemic has accelerated the shift toward digital financial solutions as physical distancing measures and public health concerns have made digital payments more appealing. This shift is evident in the increased adoption of digital payment methods, moving consumers away from cash and enabling merchants to embrace new financial technologies more readily. Digital wallets are increasingly popular across the continent, with platforms like Piggyvest and Cowrywise facilitating access to savings opportunities for millions of users. Many of these users are engaging with formal financial services for the first time, often attracted by the lower fees compared to traditional banks. The role of fintech in Africa is reshaping more than just financial transactions as it's significantly advancing broader economic empowerment. By introducing efficient and accessible financial technologies, these startups are not only generating employment but also bolstering key economic sectors. Particularly, through fintech-driven micro-insurance products<sup>13</sup>, vital support is being extended to the agriculture and healthcare sectors. These products are designed to manage risks related to agricultural uncertainties or health crises, which is crucial in regions where conventional financial services are limited or absent. This innovation provides a safety net for underserved populations, enhancing their financial security and promoting sustainable economic growth.

Also, McKinsey prospects forecast a 8x growth in fintech revenues if the penetration levels reach those of market leaders with financial services market that could grow 10% annually reaching 230 billion in revenues by 2025.

<sup>&</sup>lt;sup>12</sup> McKinsey & Company. Fintech in Africa: The end of the beginning. https://www.mckinsey.com/industries/financialservices/our-insights/fintech-in-africa-the-end-of-the-beginning?cid=eml-web

<sup>&</sup>lt;sup>13</sup> See The Landscape of Microinsurance. Published by Micro Insurance Network, Alice Merry and Johan Sebastian Rozo Calderon, Three Fin Consulting.



These elements are setting the stage for potential exponential growth in African fintech, similar to developments seen in markets like Vietnam, Indonesia, and India. Despite this, growth will not be evenly spread across Africa's 54 countries. South Africa currently dominates, holding about 40% of the market's value due to its advanced banking system. However, faster growth is expected in Ghana and Francophone West Africa with annual growth rates projected at 15% and 13%, respectively, until 2025. Key markets identified for significant fintech activity include Cameroon, Côte d'Ivoire, Egypt, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Tanzania, and Uganda, collectively representing 70% of Africa's GDP and half of its population.



## Fastest growth p.a.: 15% Ghana13% Francophone West Africa12% Nigeria and Egypt11 key markets = 70% of Africa's GDP and 50% of population

The digital maturity of these markets varies, influencing the type of financial innovations likely to succeed. In countries with developed financial and digital infrastructures like South Africa and Nigeria, advancements in regulatory technologies for anti-money laundering (AML) and know-your-customer (KYC) compliance are likely. In contrast, in emerging markets like Egypt, innovations will likely focus on insurance, banking-as-a-service, and consumer credit models.

Despite the above mentioned significant strides, the continent has produced only a few fintech unicorns, and the overall profitability of these ventures remains uncertain. This highlights the ongoing need to create conducive conditions for fintech to thrive, addressing challenges such as achieving scale, navigating varied regulatory landscapes, managing resource constraints, and establishing strong governance frameworks.

## II. DISRUPTION OF TRADITIONAL BANKING BY FINTECH PLATFORMS

#### 1. Fintech disruption

The financial sector, traditionally characterized by its reliance on established banks, is undergoing a significant transformation due to the incursion of financial technology. This disruptive force is redefining the delivery of financial services with an emphasis on efficiency and customer-centered design.

Tracing the origins of this fintech revolution to the 2008 global financial crisis highlights a pivotal shift. During this period, a diminishing trust in traditional banks coincided with a surge in demand for transparency and digital, efficient solutions. Startups and tech companies swiftly moved to innovate and address these emerging consumer needs.

Pioneering initiatives such as peer-to-peer (P2P) lending platforms and advanced digital payment services were among the first to challenge the status quo. Platforms like PayPal and Lending Club disrupted traditional financial operations by providing more user-friendly, accessible services. These early innovations laid the groundwork for a broader technological wave that swept across the financial sector.

Key technological advancements have been instrumental in propelling the fintech expansion. For instance, blockchain technology, initially linked to cryptocurrencies like Bitcoin, has broadened its scope to transform transaction and contract verification processes. Likewise, developments in artificial intelligence and machine learning have revamped data analytics, enhancing capabilities in areas such as fraud detection and predictive analysis, and facilitating the rise of automated investment services.

The impact of mobile technology on fintech cannot be overstated. It has democratized access to financial services, allowing consumers to manage their financial interactions on-the-go through mobile banking apps and digital wallets, thus diminishing the traditional reliance on bank branches.

Moreover, the fintech sector has introduced novel business models, including crowdfunding and automated investment services, which have democratized financial participation. Regulatory bodies have responded by adapting policies to foster innovation while safeguarding consumer interests and maintaining financial stability.

The ongoing evolution of fintech presents a complex array of challenges and opportunities for both traditional banks and consumers. Banks are compelled to undergo digital transformations to stay competitive, whereas consumers benefit from enhanced access to financial services. Nonetheless, they must also contend with the complexities associated with data security and privacy.

In this sense a very interesting article, Fintech Disruption in Traditional Banking: Implications for Banks and Consumers<sup>14</sup> by Dr. Vijay Singh Negi provide an analysis for the effects of the fintech in the context of banking sector disruption providing a literature review which starts from Smith (2018)<sup>15</sup> who elaborates on the transformative role of fintech firms that employ advanced technologies like blockchain and artificial intelligence to redefine the financial services landscape. These firms enhance efficiency and customer experience, often overshadowing traditional banking interfaces that are perceived as outdated. For example, McKinsey<sup>16</sup> estimated that digital finance could unlock \$3.7 trillion in economic growth by 2025, primarily through increased product and service accessibility. Smith argues that these rapid advancements force traditional banks to undertake significant digital transformations or risk obsolescence, suggesting that banks need to adopt a level of agility comparable to fintech startups, which are not burdened by outdated systems and legacy costs.

Building on this, Brown and Jones (2020)<sup>17</sup> discuss how traditional banks respond to fintech pressures by maintaining expensive legacy systems while simultaneously investing in cutting-edge technology. They highlight case studies where banks have successfully integrated fintech innovations through partnerships, allowing them to access state-of-the-art tech and business models at a fraction of the cost of in-house development. For instance, partnerships between big banks and fintech startups have led to a reduction in operational costs by up to 30% and an improvement in service delivery time by 40%, as noted by Deloitte<sup>18</sup>.

Chen et al. (2019)<sup>19</sup> focus on the consumer benefits of fintech, emphasizing the enhanced accessibility of financial services through innovations like mobile apps, digital payment platforms, and roboadvisors. These tools have democratized financial services, making them more accessible and personalized. However, the study also stresses the importance of data security, noting a significant increase in data breaches in the fintech sector by 25% from the previous year<sup>20</sup>. The authors call for stringent regulatory measures to ensure fintech companies implement robust data protection protocols to maintain user trust and security.

Lastly, Davis and White (2021)<sup>21</sup> delve into the regulatory challenges posed by the rapid growth of fintech. They outline how regulators are revising frameworks to manage the risks associated with digital financial services, such as fraud and systemic disruptions. Their research advocates for a dynamic regulatory approach that adapts to technological advancements while preventing potential financial crises, highlighting efforts by global regulatory bodies to implement measures that ensure both innovation and financial stability.

Again, according to the above mentioned study by Dr. Vijay Singh Negi between 2015 and 2023, the financial services sector witnessed a transformative shift driven by fintech innovation, significantly altering market dynamics and consumer behaviour in lending, payments, wealth management, and fintech services. Initially, traditional banks dominated the lending market with an 85% share, but fintech interventions reduced their hold to 70%, with fintech firms claiming 30% of the market. This shift

<sup>&</sup>lt;sup>14</sup> Fintech Disruption in Traditional Banking: Implications for Banks and Consumers, Dr. Vijay Singh Negi Associate Professor/ Govt. Degree College, New Tehri. JETIR September 2023, Volume 10, Issue 9. http://www.jetir.org(issn-2349-5162/.

<sup>&</sup>lt;sup>15</sup> Smith, J. (2018). "The Fintech Revolution: How Traditional Banks are Adapting." Journal of Banking and Finance Trends,

<sup>42(3), 15-30.</sup> 

<sup>&</sup>lt;sup>16</sup> See Digital Finance for All: Powering Inclusive Growth in Emerging Markets" by McKinsey Global Institute.

<sup>&</sup>lt;sup>17</sup> Brown, A., & Jones, M. (2020). "The Competitive Landscape: Traditional Banks vs. Fintech Firms." Banking Quarterly Review, 38(4), 12-27

<sup>&</sup>lt;sup>18</sup> See Connecting Global Fintech: Hub Review 2016, Deloitte.

<sup>&</sup>lt;sup>19</sup> Chen, L., et al. (2019). "Consumer Adoption of Fintech Services: A Comparative Study." International Journal of Consumer Studies, 37(5), 620-634.

<sup>&</sup>lt;sup>20</sup> Cost of a Data Breach Report 2020, IBM

<sup>&</sup>lt;sup>21</sup> Davis, R., & White, S. (2021). "Regulatory Challenges in the Fintech Era: Striking a Balance." Journal of Financial Regulation, 25(2), 45-60.

underscores the growing preference for fintech solutions which offer more efficient and user-friendly alternatives to conventional banking practices.

Similarly, in the payments sector, traditional banks experienced a significant decline in market share from 90% to 60%, while fintech solutions rose to claim 40% of the market. This redistribution indicates a robust consumer shift towards fintech payment solutions that combine convenience with advanced technology.

In asset management, while traditional banks maintain a strong presence with 80% of the market, down from 95%, fintech firms have begun to carve out a 20% share by offering innovative wealth management services that resonate with tech-savvy consumers.

The consumer adoption rates of fintech services further illustrate this trend. Mobile banking app usage surged from 30% in 2015 to 80% in 2023, digital payment platforms from 20% to 70%, and robo-advisory services from 5% to 25%. These statistics highlight a significant consumer pivot towards digital financial solutions that enhance accessibility, personalize financial interactions, and offer greater control over personal finances.

This data help to determine how fintech companies have significantly reshaped the financial services landscape, presenting formidable competition to traditional banks. This shift is reflected in the changing market shares where fintech's innovations in technology—particularly in lending and payments—have begun to erode the dominance of traditional banks. Initially, banks held a dominant market share in lending, but fintech innovations have reduced this significantly. Similarly, in the payments sector, the advent of mobile banking applications and digital payment platforms has shifted consumer preferences towards more agile and technologically advanced fintech solutions, decreasing traditional banks' market share.

This competitive landscape has compelled traditional banks to invest heavily in digital transformation. They are adopting new technologies to enhance customer experience and streamline operations, often through partnerships with fintech firms. These collaborations not only help banks access advanced technologies and innovative business models more cost-effectively but also allow them to retain their relevance in the digital age.

Moreover, the regulatory landscape for fintech is dynamic and complex, pushing traditional banks to continuously navigate evolving regulations to ensure compliance. This scenario is complicated further by the need to maintain high standards of data security to protect against increased risks of cyber threats and data breaches.

Additionally, fintech's rise has boosted consumer access to financial services, making them more convenient and personalized through tools like robo-advisors. However, it also raises concerns about data security and demands robust regulatory measures to ensure comprehensive consumer protection. Overall, fintech's disruption has not only challenged the market share of traditional banks but also transformed consumer behaviour and expectations, driving a rapid evolution in financial services towards more integrated, technology-driven solutions. This shift underscores the ongoing need for traditional banks to innovate and adapt in response to an increasingly digital and competitive landscape.

## 2. Cost dynamics

The financial services sector is experiencing a significant transformation, propelled by the integration of fintech innovations that are fundamentally altering traditional financial operations and significantly lowering costs. This chapter will explore three key fintech technologies—blockchain, artificial intelligence (AI), and algorithmic trading together with high frequency trading. These innovations are widely recognized within the industry for their potential to enhance cost efficiency. Their capabilities in

streamlining operations, enhancing speed and accuracy, and reducing labour-intensive processes make them pivotal in the ongoing evolution of financial practices.

#### a. Blockchain

For the blockchain part an article providing clear evidence of cost reduction is given by "Cost efficient management of complex financial energy trading systems: Knowledge-based blockchain technique" by Qi Liua, Pengbo Wanb, Fen Chenb and Weiting Lic.

In recent developments within Smart Cities (SCs), blockchain technology has emerged as a transformative force in the management of the Energy Internet (EI), especially in conjunction with the Internet of Things (IoT). The integration of these technologies enhances the reliability, resiliency, and sustainability of urban energy systems. Blockchain technology addresses several key operational and security challenges, leading to significant cost reductions.

Blockchain's primary contribution to cost efficiency comes through its ability to secure sensor networks that are essential to the IoT framework. This technology ensures robust security without the need for centralized control, thus reducing the costs associated with managing and securing vast networks of energy data. By employing decentralized consensus mechanisms and cryptographic security, blockchain minimizes the vulnerability to attacks and system failures, which are often costly to mitigate in traditional energy networks.

Moreover, blockchain facilitates decentralized transactions within the EI, allowing direct peer-to-peer interactions. This capability eliminates the reliance on traditional energy distribution intermediaries, such as utility companies, which often impose additional costs through fees and complex administrative structures. By enabling direct transactions between producers and consumers of energy, blockchain significantly reduces transaction costs and simplifies the billing process.

Operational efficiency is another area where blockchain technology excels. It automates many processes including real-time metering and billing, reducing the need for manual intervention and the associated administrative overheads. This not only cuts costs but also enhances the accuracy and efficiency of transactions, leading to smoother and faster operations within the smart city infrastructure.

The transparency inherent in blockchain technology also reduces the need for frequent audits and extensive compliance checks. All transactions on a blockchain are recorded on a secure, immutable ledger, visible to all network participants. This transparency ensures that transactions can be verified independently by users, significantly lowering the likelihood of fraud and reducing the costs related to regulatory compliance and auditing.

Lastly, blockchain supports the integration of distributed energy resources, such as solar panels and microgrids, into the urban energy network. It makes the incorporation of these smaller-scale, often renewable energy sources more economically viable by reducing the transactional and operational barriers typically associated with their use. This support not only drives down the costs related to energy production and distribution but also promotes the adoption of renewable energy solutions.

## b. Al

To analyse the context of AI which will lead us also to algorithmic trading, we will focus on "Artificial intelligence techniques in financial trading: A systematic literature review" by Fatima Dakalbab, Manar Abu Talib b, Qassim Nasir and Tracy Saroufil. In fact, this research considers that financial markets, inherently complex due to their non-linear and dynamic nature, are significantly influenced by various factors such as economic news and global events. The integration of Artificial Intelligence (AI) in these markets marks a transformative shift, enhancing the efficiency, security, and personalization of

financial services. This advent of financial technology (FinTech) utilizes AI to innovate and resolve longstanding challenges in trading, investments, and risk management.

Al technologies automate routine tasks, enable advanced risk assessments, and personalize customer interactions, significantly impacting banking, investments, and insurance sectors. However, the integration of AI within financial markets comes with challenges, including data quality and handling the dynamic nature of economic indices. These challenges necessitate sophisticated AI-driven analytical approaches to ensure accurate trading decisions.

Al-enhanced algorithmic trading exemplifies this shift by providing cost-effective, accessible tools that leverage data to predict market trends and make unbiased investment decisions, free from human emotional biases. Despite its widespread adoption, there remains a gap in the systematic review of Al's applications in trading. This review addresses this by analysing Al techniques used from 2015 to 2023, exploring their effectiveness in predicting market behaviours and aiding traders in maximizing profitability. This analysis aims to enhance understanding of Al's role in financial trading and guide future innovations in this rapidly evolving field.

The advent of artificial intelligence has revolutionized financial markets, enhancing the efficiency, security, and personalization of financial services. Financial technology, or FinTech, utilizes these technological advancements not only for traditional financial activities like trading and investments but also in automating risk management and insurance processes. On the analytical front, financial trading heavily relies on both fundamental and technical analysis. Fundamental analysis evaluates the impact of external economic factors on the market, aiming to determine the intrinsic value of financial securities. This approach involves a detailed examination of economic indicators and market news, making it crucial for long-term trading strategies. On the other hand, technical analysis focuses on statistical methods to identify price patterns and market trends from historical data, using various indicators like moving averages and oscillators. This method is particularly valuable for traders seeking to capitalize on short-term market movements, as it provides actionable insights based on past price behaviours.

Both analytical methods offer distinct advantages, but when combined, they provide a comprehensive toolset for traders to navigate the complexities of financial markets efficiently. This synergy not only enhances decision-making accuracy but also reduces costs related to poor investment choices and inefficient market analyses.

Algorithmic trading utilizes advanced algorithms to automate trading, significantly enhancing speed and accuracy while reducing costs. Through back testing, traders refine these algorithms using historical data, which allows for fine-tuning of strategies to optimize performance. Once validated, these models are deployed and continuously monitored, adjusting to market changes to maintain effectiveness. This process not only ensures cost efficiency but also improves the precision of trades, leveraging computational power to outperform traditional human trading methods.

According to the authors In the literature on AI in financial trading, extensive reviews reveal a significant focus on machine learning techniques for enhancing quantitative trading strategies as, while deep learning models offer advanced predictions, they sometimes do not surpass traditional methods due to data limitations.

Further studies explore the intersection of AI and financial technologies, highlighting AI's transformative potential in banking, investments, and regulatory technologies (RegTech) by discussing both the opportunities and risks presented by AI in modernizing financial services and ensuring regulatory compliance.

This broad spectrum of research underscores the growing importance of AI in financial markets, pushing the boundaries of traditional trading systems towards more efficient, automated solutions that significantly reduce operational costs and enhance decision-making processes. The extensive data collected from 2015 to 2023 aids in identifying trends, gaps, and future directions in AI applications, providing a foundation for ongoing innovations in financial trading.

The research's survey uses Kitchenham and Charters' Systematic Literature Review framework, consisting of planning, conducting, and reporting phases. It identifies key AI research in financial trading, utilizing a structured search strategy across multiple digital libraries and drawing from a pool of 143 papers, emphasizing the evolution of AI applications from basic machine learning to complex deep learning and reinforcement learning strategies across different market types. Key stages include setting research objectives, formulating search terms, selecting studies, and synthesizing data to uncover trends and insights from 2015 to 2023. The survey highlights the growing influence of AI in optimizing trading strategies, enhancing prediction accuracy, and reducing costs, offering a comprehensive overview of state-of-the-art AI tools in financial markets. The research into various trading markets like stock, FOREX, and cryptocurrency reveals focused analysis on how AI-driven trading platforms can reduce costs. These platforms employ machine learning techniques to predict market trends and asset prices with greater accuracy, reducing the reliance on manual forecasting and human error. Automated trading strategies, which include both fundamental and technical analysis, have been crucial in enhancing transaction efficiency. Al models streamline operations and offer precise predictions, optimizing trading decisions, and significantly lowering transactional costs. The use of technical indicators such as moving averages and oscillators further aids in understanding market behaviours, potentially reducing costs associated with poor trading decisions. Overall, the integration of AI in trading not only improves financial predictions but also demonstrates a clear path to cost reduction in trading operations. In the study of AI approaches within financial trading, deep learning, reinforcement learning, and deep reinforcement learning emerged as predominant techniques due to their advanced capabilities in handling complex, dynamic market conditions. These methods enhance predictive accuracy and operational efficiency, significantly reducing costs associated with human error and manual intervention in trading strategies. Specifically, deep learning processes large data sets to identify nuanced patterns, while reinforcement learning adapts strategies based on real-time market feedback, optimizing financial outcomes and reducing costly errors. This sophisticated integration of Al not only streamlines trading operations but also delivers cost-effective solutions by minimizing risks and improving decision-making processes.

This research is concluded assessing that the systematic review of AI techniques in financial trading has illuminated cost reduction patterns through the adoption of advanced AI technologies. By analysing various financial markets, notably stock, FOREX, and cryptocurrency, it is evident that AI enhances efficiency and accuracy in trading. Notably, deep learning and reinforcement learning techniques, preferred for their robust predictive capabilities, have minimized operational costs and reduced the necessity for human oversight.

The integration of technical analysis indicators, primarily momentum oscillators like RSI, underscores a shift towards automated processes that streamline operations and lower transaction costs. The findings that only 16% of solutions fully automate the trading process indicate significant potential for cost reduction through increased automation.

Additionally, the use of comprehensive data sources such as Yahoo Finance and the application of hybrid AI models suggest that more integrated and sophisticated systems can further optimize trading strategies, thereby reducing costs associated with errors and inefficiencies.

#### c. Algorithmic trading and high frequency trading

Financial markets have undergone significant transformations with the integration of algorithmic trading, which uses sophisticated algorithms to automate trading decisions. This approach allows for rapid execution of large volumes of orders, enhancing efficiency and reducing costs by minimizing the bid-ask spread and exploiting market inefficiencies quickly.

As technology has evolved, algorithmic trading has given rise to high-frequency trading (HFT), which operates on an even faster scale, executing transactions in milliseconds to capitalize on fleeting market

opportunities. While HFT enhances liquidity and reduces trading costs, it also brings challenges related to market stability and fairness.

The nuances of these trading technologies, particularly their impact on financial markets, will be explored further based on insights from the article "Computerized and High-Frequency Trading" by Michael A. Goldstein, Pavitra Kumar, and Frank C. Graves, providing a detailed examination of both the benefits and the complexities introduced by these advanced trading mechanisms.

The rapid advancement in financial technologies, specifically through the implementation of algorithmic and high-frequency trading, has dramatically reshaped the landscape of market operations. This transformation is characterized by the ultra-fast submission and execution of orders, where trading speeds have escalated to the point that latencies are now measured in microseconds, as noted by the SEC (2010). These developments allow firms to exploit brief, often minute, discrepancies in market prices that could not be accessed without advanced computer algorithms.

High-frequency trading, a subset of algorithmic trading, focuses on leveraging high-speed systems to engage in strategies that often result in extremely short holding periods. The essence of HFT is its ability to execute numerous orders at lightning speed, accumulating profits through very narrow margins over a vast number of transactions. This efficiency in trading contributes significantly to cost reduction by minimizing the capital exposure and leveraging tiny, incremental gains across many transactions.

However, the rise of HFT has sparked considerable debate regarding its impact on market stability and fairness. Rapid trading strategies can lead to significant market aberrations when algorithmic models interact unexpectedly or malfunction. These sudden shifts can distort fundamental market values temporarily if the positions cannot be unwound or reversed quickly. The SEC has raised concerns about the fairness of such fast-paced trading strategies, questioning whether the advanced order routing systems used by proprietary traders create a disparity in market access.

Despite potential risks, the implementation of HFT and more sophisticated algorithmic trading methods has generally led to lower transaction costs and narrower bid-ask spreads. Studies suggest that as market participation by high-speed algorithmic traders increases, overall market liquidity improves. Yet, this comes at the cost of potential systemic risks, highlighted by notable market disturbances like the 2010 Flash Crash<sup>22</sup>. These incidents have fuelled ongoing debates about the societal benefits of HFT versus its costs in terms of market stability and the integrity of financial systems.

This evolving scenario underscores the dual-edged nature of rapid, computerized trading technologies: while they offer unprecedented efficiencies and cost reductions, they also pose new challenges in market regulation and oversight, necessitating a careful evaluation of their long-term impact on financial markets which we will furtherly consider in chapter 3 of this work.

According to the above mentioned article HFT gained traction after the SEC's 1998 regulation of alternative trading systems, quickly expanding from less than 10% of U.S. equity trades in the early 2000s to about 50% by 2012. This rapid adoption also mirrored globally with significant volumes in European and Asian markets. The shift to HFT has drastically reduced trading times from seconds to microseconds, enhancing market efficiency and reducing costs. However, recent years have seen a decline in HFT profitability due to rising operational costs and less favourable market conditions. As a result, HFT firms have diversified into trading international stocks and currencies, though this hasn't fully offset the declines in traditional markets. This transition reflects HFT's sensitivity to technological advancements and market dynamics, highlighting its ongoing adaptation to changing financial landscapes.

HFT strategies typically involve trading firms' own capital, including broker-dealer proprietary trading desks and hedge funds like Renaissance Technologies and DE Shaw. These firms, often based in strategic locations like New York and Chicago, leverage their proximity to major exchanges to minimize latency issues critical for successful HFT operations, as geographic closeness significantly impacts

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<sup>&</sup>lt;sup>22</sup> See SEC/CFTC 2010

transmission speeds and trading effectiveness. HFT practices frequently involve rapid order placement and cancellation, which are not meant to be executed but to test market waters—a tactic known as "pinging" to gauge market liquidity. This strategy can lead to what is known as "quote stuffing," where markets are overloaded with orders that are quickly cancelled, posing risks to market stability by increasing volatility and trading costs, and potentially degrading market quality.

Most HFT strategies can be categorized into four main types: Automated Liquidity Provision, Market Microstructure Trading, Event Arbitrage, and Statistical Trading. These strategies benefit from the speed of execution, where even milliseconds can significantly affect the profitability of trades. For instance, HFT firms might capitalize on events like earnings announcements by analysing news with algorithms to execute trades based on keywords within milliseconds of the release. Additionally, HFT is used in statistical arbitrage to exploit temporary price inefficiencies across correlated securities.

Building on the emphasis on speed and efficiency, the escalation of high-speed and high-frequency trading (HFT) has driven exchanges to fiercely compete in lowering trade execution times, or latencies. Major exchanges have invested significantly to upgrade their systems, as highlighted by Hasbrouck and Saar (2013), aiming to reduce the time required to send information to traders. For instance, the London Stock Exchange's TradElect system introduced in 2007, promised an average 10 millisecond turnaround for trades, a stark contrast to earlier speeds.

This reduction in latency is crucial for HFT firms, as each technological upgrade can significantly boost their trading activities, as shown by Brogaard, Hendershott, Hunt, and Ysusi (2014) on the London Stock Exchange. The race for speed reaches to the extent that the physical distance between traders becomes a critical factor. Garvey and Wu (2010) demonstrate that traders geographically distant from financial centres are at a distinct disadvantage due to speed limitations, including the fundamental limit imposed by the speed of light.

To combat these limitations and gain a competitive edge, HFT firms often resort to "co-location," placing their servers within or very close to the data centres of exchanges and electronic communication networks. This practice minimizes delays in order execution and is essential for firms engaged in strategies that depend on ultra-low latency. Exchanges have recognized the profitability of offering co-location services and have expanded these offerings globally, accommodating the growing demand from HFT firms. This trend underscores the ongoing evolution and specialization within financial markets, where milliseconds can equate to significant financial advantages or losses.

Following the discussion on high-frequency trading (HFT) strategies and their market impact, it's essential to consider how the very nature of computerized trading has evolved to prioritize extreme speed. Exchanges globally are now focused on facilitating faster trade execution times to accommodate the needs of HFT. As noted by Hasbrouck and Saar (2013), exchanges have invested substantially to decrease the time it takes to disseminate information to customers, thereby enhancing the attractiveness of their platforms for HFT operations.

This race towards minimal latency has led to significant technological advancements. For instance, as reported by MacDonald (2007), the London Stock Exchange introduced the TradElect system that could handle 3,000 orders per second with an average processing time of just 10 milliseconds. Similar improvements have been observed in the U.S., where the New York Stock Exchange dramatically reduced its order execution time from several seconds to mere milliseconds, reflecting a global trend towards microsecond latencies.

This technological race has consequences. Firms closer to major financial centres benefit disproportionately due to reduced latency, as proximity allows for quicker reaction times to market data. This is illustrated by the strategic placement of HFT servers in co-located facilities near exchanges' data centres, which minimizes delay in order execution. Exchanges have responded to this demand by expanding co-location services, thus generating new revenue streams while fostering a competitive trading environment that benefits from high-speed data transmission technologies.

Addressing concerns about the fairness of HFT, there's significant debate over whether it creates an uneven playing field. The SEC has raised questions about whether tools like co-location and sophisticated algorithms offer an unfair advantage to high-frequency traders who can afford them, potentially sidelining long-term investors who cannot. The effectiveness of Intermarket Sweep Orders (ISOs) in circumventing traditional trade queues further exemplifies this concern, as they are typically not accessible to regular investors.

Critics argue that such practices may not only disadvantage smaller traders but also compromise market integrity. Reports have surfaced, such as those by Patterson, Strasburg, and Pleven (2013), suggesting that certain exchanges had system loopholes that high-speed traders exploited, gaining transaction information milliseconds before the wider market. These instances highlight the need for a rigorous regulatory framework to ensure fair access to market data and trading opportunities.

In response, regulatory bodies like the SEC are examining whether market rules need adjustments to prevent high-speed traders from excessively dominating the trading landscape. This includes questioning the fairness of current market structures and whether certain high-speed trading practices should be curtailed or better regulated to ensure a level playing field for all market participants.

High-frequency trading (HFT) and algorithmic trading (AT) have profoundly reshaped market dynamics by significantly reducing operational costs and increasing the efficiency of trading processes. These technologies have allowed trading firms to minimize the time it takes to execute and confirm transactions, effectively reducing the costs associated with trading delays and manual errors.

HFT, in particular, leverages advanced computational technologies to execute a large number of orders at very high speeds. These capabilities enable traders to capitalize on minute price discrepancies that may exist only for fractions of a second. By automating the trading process, HFT reduces the need for human intervention, which lowers labour costs and minimizes the likelihood of costly manual mistakes. Moreover, both HFT and AT contribute to narrower bid-ask spreads, a direct benefit for market liquidity that translates into lower transaction costs for all market participants. The efficiency brought about by these rapid trading technologies means that information is incorporated into prices faster, potentially leading to more accurate market pricing.

However, it's important to note that the infrastructure required to support such rapid trading activities like sophisticated data centres and proximity hosting for reduced latency can involve substantial initial and ongoing investments. While larger firms might absorb these costs due to the volume of their trading activities, smaller players may find the cost barrier prohibitive.

In conclusion I want to add that HFT and algorithmic trading AT have significantly influenced market dynamics by reducing trading costs and enhancing market efficiency. Studies such as those conducted by Brogaard, Hendershott, and Riordan (2014)<sup>23</sup> have demonstrated that HFT contributes to narrower bid-ask spreads, directly lowering transaction costs for all market participants and promoting more competitive pricing structures. This effect is corroborated by a 2010 U.S. Securities and Exchange Commission report<sup>24</sup>, which highlighted the broader reduction in transaction costs due to technological advancements and the adoption of algorithmic strategies, benefiting both retail and institutional investors.

Further, the work of Hendershott, Jones, and Menkveld (2011)<sup>25</sup> supports the assertion that algorithmic trading improves market efficiency by facilitating the rapid incorporation of new information into prices, thereby reducing the costs associated with timing discrepancies and price discovery. Similarly, research

<sup>&</sup>lt;sup>23</sup> Brogaard, J., Hendershott, T., & Riordan, R. (2014). "High-frequency trading and price discovery". *Review of Financial Studies*.

 <sup>&</sup>lt;sup>24</sup> U.S. Securities and Exchange Commission (SEC). (2010). "Concept Release on Equity Market Structure". SEC Release No. 34-61358.

<sup>&</sup>lt;sup>25</sup> Hendershott, T., Jones, C.M., & Menkveld, A.J. (2011). "Does Algorithmic Trading Improve Liquidity?" *Journal of Finance*.

by Angel, Harris, and Spatt (2011)<sup>26</sup> points out the long-term downward trend in both explicit and implicit trading costs, which is closely tied to the rise of electronic and algorithmic trading platforms. These findings collectively suggest that HFT and AT not only enhance the operational aspects of trading but also contribute to more robust and cost-effective market mechanisms.

#### 3. Low-Frequency Trading

The significant differences between low frequency (LFT) and high frequency trading types underscore the need for regulatory distinctions, such as those made by the European Securities and Markets Authority (ESMA), which recognizes the unique operational characteristics and market impacts of HFT. In contrast, LFT is treated under more conventional regulatory frameworks, reflecting its closer alignment with traditional trading activities<sup>27</sup>. We will further develop ESMA guidelines on algorithmic trading in chapter IV of this thesis.

Focusing on Low-Frequency Trading<sup>28</sup>, it represents a strategic approach to investments, emphasizing longer hold periods and fewer transactions, contrary to the fast-paced tactics seen in high-frequency trading. This method is anchored in foundational investment philosophies such as buy-and-hold, value investing, and contrarian strategies that capitalize on market inefficiencies. By employing fundamental analysis, LFT focuses on selecting stocks that offer intrinsic value and promising long-term growth, assessing a company's financial health, management quality, and market position alongside broader macroeconomic factors and industry trends.

One of the principal advantages of LFT is the reduction of transaction costs. Frequent trading incurs significant expenses, including commissions and bid-ask spreads, which can erode investment returns over time. LFT counters this by minimizing the number of transactions, thus preserving capital gains which are further enhanced by the favourable tax treatment on long-term investments. The tax rates applied to long-term capital gains are generally lower than those for short-term trades, presenting a compelling case for patient, strategic asset accumulation.

Moreover, LFT offers the potential for more stable returns by shielding investors from the whims of shortterm market volatility. This strategy allows investors to participate in the long-term growth of the markets, benefitting from the power of compounding, which can result in substantial wealth accumulation. The effectiveness of LFT in reducing portfolio volatility and providing stable growth over time is well-documented in investment literature, including works by notable economists who advocate for the long-term, patient capital management.

However, LFT is not without its challenges. The strategy involves significant capital lock-in, which can reduce liquidity and flexibility, potentially causing investors to miss out on short-term opportunities. Furthermore, long-term investments are susceptible to systemic risks and business cycle shifts that could depreciate asset values over extended periods. The lack of quick adaptability means that LFT portfolios might not capitalize on market highs driven by fleeting technological or sectoral trends.

Despite these challenges, LFT plays a crucial role in modern investment portfolios, particularly in the context of retirement planning, where the focus is on risk mitigation and capital preservation over decades. Tools and resources available today, including sophisticated financial planning software and comprehensive market analysis platforms, support the implementation of LFT by offering detailed analytics and long-term projections. These technologies enable investors to strategize effectively, balancing risk and return by diversifying across various asset classes such as equities, bonds, and real estate.

<sup>&</sup>lt;sup>26</sup> Angel, J., Harris, L., & Spatt, C. (2011). "Equity Trading in the 21st Century". *Quarterly Journal of Finance*.

<sup>&</sup>lt;sup>27</sup> See MiFID II and MiFIR

<sup>&</sup>lt;sup>28</sup> See Questions and Answers On MiFID II and MiFIR market structure topics, 13 October 2023 ESMA70-872942901-38

Looking ahead, the role of Low-Frequency Trading (LFT) is poised to adapt dynamically to both demographic shifts and technological advancements. As populations in many developed nations age, there is a growing emphasis on stable, long-term investment returns, particularly in the context of retirement planning. LFT's suitability for generating predictable, sustained growth over extended periods makes it increasingly relevant for this demographic trend. Investors are looking for investment strategies that minimize risk and provide financial security for their retirement years, a need that LFT is well-equipped to meet.

In parallel, technological advancements are set to significantly influence the future of LFT. The integration of big data analytics and artificial intelligence (AI) into investment strategies offers promising enhancements to traditional LFT approaches. AI algorithms can analyse vast amounts of historical financial data to identify long-term trends and investment opportunities that may not be apparent through traditional analysis methods. This could lead to more informed decision-making and improved strategic positioning, allowing LFT portfolios to be both safer and potentially more lucrative.

Moreover, advancements in machine learning could enable more sophisticated risk assessment models. These models can factor in a broader range of variables, including global economic indicators, political stability, and emerging market trends, to forecast long-term performance with greater accuracy. Such tools would be invaluable in managing the risks associated with long-term investments, providing a deeper understanding of potential market shifts and their impacts on portfolio performance. Blockchain technology also presents a transformative potential for LFT by enhancing transparency and security in financial transactions. Blockchain can facilitate clearer and more reliable records of asset ownership and transaction history, reducing the risk of fraud and error in long-term investments. Additionally, the use of smart contracts could automate many of the compliance and administrative tasks associated with managing long-term investments, reducing costs and increasing efficiency.

As these technologies mature, they could dramatically alter the landscape of low-frequency trading, making it not only a strategy for risk-averse, long-term investors but also an increasingly powerful tool for capitalizing on the benefits of technological innovation in financial markets. The future of LFT, therefore, lies in its ability to seamlessly integrate these technological advancements, enhancing both the security and profitability of long-term investment strategies. This evolution will likely attract a broader range of investors, expanding the influence of LFT in the global financial ecosystem.

Building upon our exploration of algorithmic trading strategies, it's essential to delve deeper into the stark contrasts between High-Frequency Trading (HFT) and Low-Frequency Trading (LFT), particularly focusing on their strategic differences without redundancy.

HFT is characterized by its reliance on speed and technological prowess, capturing fleeting inefficiencies in the market. This approach necessitates the use of sophisticated algorithms that execute hundreds of trades in milliseconds, often requiring colocation services to minimize latency. The primary aim is to exploit small price discrepancies that may exist for only a fraction of a second.

In contrast, LFT takes a measured approach, prioritizing long-term investment horizons over immediate gains. Strategies here involve substantial fundamental analysis, assessing a company's potential for growth over months or years, rather than reacting to momentary market movements. LFT traders utilize technology to enhance the depth of their market analysis, not necessarily the speed of their transaction execution.

The operational tempo of HFT introduces a unique set of market risks and regulatory challenges. Rapid trading can amplify market volatility and lead to systemic risks, prompting stringent oversight from financial authorities. Regulators scrutinize HFT practices closely, implementing safeguards to prevent market manipulation and ensure fair trading practices.

Conversely, Low-Frequency Trading (LFT) aligns more closely with traditional trading practices and attracts less stringent regulatory scrutiny compared to its counterpart, High-Frequency Trading (HFT). The distinctions between LFT and HFT extend beyond technological prowess or performance metrics; they fundamentally differ in their roles within the financial ecosystem. While HFT leverages algorithmic

speed to exploit short-term market inefficiencies, primarily focusing on rapid execution and cost minimization, LFT plays a more pivotal role in the strategic reshaping of asset management.

LFT bridges the gap between traditional asset management and modern technological integration. It supports a shift from short-term trading to long-term investment strategies, emphasizing risk mitigation, stability, and sustainable wealth accumulation. This approach not only aligns with the conservative goals of traditional asset management but also enhances these strategies through the use of advanced data analytics and digital tools. By doing so, LFT not only complements but actively replaces traditional asset managers, positioning itself as a crucial element in the industry's evolution towards more integrated, technology-driven financial management.

Furthermore, LFT's regulatory environment reinforces its transformative role. It promotes transparency and ethical investment practices that prioritize long-term financial planning over the high-speed, high-risk operations typical of HFT. As such, LFT is increasingly viewed not merely as an alternative trading practice but as a foundational force driving the asset management industry towards a future where technology and traditional financial wisdom converge seamlessly.

This transformative impact of LFT is pivotal as it facilitates a smoother transition for institutions and investors towards embracing more robust, technologically enabled asset management practices. By championing the principles of responsible and strategic investment, LFT is reshaping the landscape, fostering a new era where technology enhances rather than replaces the core values of traditional finance.

The cost structure of each trading type also diverges significantly. HFT incurs high operational costs, including substantial investments in technology and infrastructure, alongside the costs associated with high turnover rates, such as exchange fees and market impact costs. These expenses necessitate a high volume of successful trades to remain profitable, a stark difference from LFT's cost-effective model which minimizes transaction costs and maximizes tax efficiency through favourable long-term capital gains rates.

Furthermore, the risk profile of HFT is distinctively high. The speed at which trading strategies are executed can lead to significant exposure to systemic errors and market anomalies. Such rapid trading strategies can also result in substantial financial losses within a very short period, should the market move unfavourably against the positions held.

LFT, on the other hand, advocates for a risk-averse approach, focusing on the stability and potential of investments over extended periods. This strategy inherently reduces exposure to short-term market volatility and systemic risks, providing a buffer against the kind of quick, adverse market movements that can affect HFT strategies.

Technological advancements have impacted both strategies differently. In HFT, improvements in processing power and algorithmic efficiency continue to push the boundaries of trading speed and sophistication. Meanwhile, in LFT, technology serves to augment the analytical capabilities, providing comprehensive data analysis tools that support more informed and strategic investment decisions.

In essence, the divide between HFT and LFT is profound, reflecting differing philosophies, operational tactics, regulatory landscapes, and risk management approaches. Understanding these differences is crucial for investors aligning their strategies with their financial goals and risk tolerance, ensuring they choose the approach that best suits their needs in the evolving landscape of financial markets.

4. Transforming Asset Management through Technological Integration

In the evolving landscape of asset management, PwC's 2023 Global Asset and Wealth Management Survey<sup>29</sup> offers a stark depiction of an industry at a critical juncture, where embracing technological innovation is not merely an option but a necessity for survival. The survey underscores a significant transformation driven by digital advancements, with the industry facing a precipitous decline in global assets under management (AuM) in 2022, marking the steepest fall in a decade to \$115.1 trillion, nearly 10% below the 2021 high of \$127.5 trillion. However, it also forecasts a rebound by 2027, with AuM expected to grow to \$147.3 trillion, reflecting a compound annual growth rate (CAGR) of 5%.



CAGR	2018-2022	2027 Low	2027 Base	2027 Best
Global AuM	5,9%	3,7%	5,0%	6,5%
<b>Mutual Funds</b>	7,4%	4,2%	5,3%	6,7%
Mandates	3,2%	2,8%	4,5%	6,0%
Alternatives	8,9%	4,4%	5,6%	7,0%

The pressure on asset managers to adapt is compounded by shifts in investment strategies—from active to passive management and a growing emphasis on private markets—which highlight a broader trend towards transparency, cost efficiency, and enhanced data analytics. Technological tools such as big data, AI, and blockchain are becoming indispensable in navigating market volatility and interest rate uncertainties, enabling managers to identify unique investment opportunities and optimize portfolio performance. This technological integration is expected to drive a significant increase in revenues, with global asset management revenues projected to reach \$622.1 billion by 2027, up from \$599.4 billion in 2021.

<sup>&</sup>lt;sup>29</sup> Asset and wealth management revolution 2023: The new context, www.pwc.com/awm-revolution.



Moreover, the survey reveals a strategic consolidation within the industry, with many asset managers considering mergers to augment capabilities and expand market share. This trend is indicative of the increasingly competitive environment that demands not only scale but also technological proficiency to operate effectively. The anticipated control of half of all mutual fund assets by the top ten asset managers by 2027 exemplifies this shift towards larger, technologically adept players dominating the market.

Asset management firms are thus finding themselves at a crossroads, where the integration of advanced technologies is key to enhancing operational efficiencies and investment outcomes. This transformation is not just about survival but about redefining the contours of asset management to align with a digital-first world, where algorithmic trading, predictive analytics, and automated advisory services become the standard.

Building upon the transformational shifts in the asset and wealth management (AWM) industry, the retail market emerges as a crucial arena for growth, leveraging new opportunities within high-net-worth (HNW) and mass affluent segments. As delineated in PwC's projections, these investor classes are increasingly seeking diversified products, propelled by access to private markets and the dynamic allocation in investments, including a substantial rise in ETFs. The market trends predict an escalation in private market accessibility due to regulatory changes like the European Long-Term Investment Funds (ELTIF) and modifications to U.S. retirement plans allowing non-traded assets such as private REITs. This pivot is not merely democratizing investment; it primarily caters to affluent investors, with assets expected to swell to \$139.6 trillion by 2027.

This shift towards retail is underscored by a generational transfer of wealth, particularly from baby boomers to millennials, which intensifies the need for wealth management services to integrate technology and adapt to the preferences of younger, tech-savvy clients. These trends point to a burgeoning demand for investments that align with ESG principles, digital assets, and further exploration of private markets. The advent of ETFs, especially active ETFs, is particularly noteworthy. Asset managers predict a surge in demand from individual investors for active ETFs in the next two to three years, reflecting an industry pivot towards offerings that combine the advantages of active management with the traditional benefits of ETFs, such as lower costs and greater transparency.

In the rapidly evolving world of asset and wealth management, technology has emerged as a transformative force, reshaping both market approaches and client expectations. Almost all

institutional investors (90%) acknowledge that disruptive technologies like big data, AI, and blockchain not only enhance investment outcomes but are crucial for staying competitive. Asset managers, on their part, are leveraging these technologies extensively, although aligning them with evolving investor expectations remains a complex challenge.

The adoption of digital-first strategies and direct investment platforms particularly appeals to a younger, tech-savvy demographic. Individualized indexing is becoming increasingly popular, attracting investors interested in tax optimization, ESG considerations, and more precise investment strategies through algorithmic portfolio construction. Projections indicate that assets under management for directly indexed portfolios are set to expand significantly, from a substantial increase over the past years to an expected US\$1.47 trillion by 2027, demonstrating a robust annual growth rate.

Moreover, the financial industry is witnessing a fundamental shift in its operational infrastructure. Technologies like tokenization are simplifying the trading and ownership structures of securities through blockchain, allowing for more efficient trade settlement and custodianship processes. This shift is poised to redefine the engagement and management of securities, potentially making traditional infrastructures obsolete.

The integration of AI continues to push the boundaries of what's possible in asset management. The use of robo-advisors, for instance, is expected to manage over US\$5.9 trillion by 2027, a significant jump from previous figures. These advancements enable more nuanced analysis of both structured and unstructured data, enhancing trading strategies and operational efficiencies.

As asset management firms navigate an environment characterized by intense competition and cost pressures, the industry is witnessing a significant transformation in fee structures and competitive dynamics. The total expense ratios (TERs) for both active and passive funds are forecasted to continue their decline, with active funds expected to see a more rapid reduction. By 2027, the TER for active funds is anticipated to decrease by 12% (to 59 bps), while passive funds will see a reduction of 9% (to 13 bps).





This trend is driven not only by investor demands for lower fees but also by large asset managers leveraging scale and technological advancements to reduce costs and enhance efficiency.

This environment is fostering a surge in mergers and acquisitions (M&A) within the asset and wealth management industry, with about 73% of asset managers considering strategic consolidations to expand market share, access new segments, and mitigate risks. Such consolidations are seen as essential for firms aiming to navigate the challenges posed by increased competition and the need for efficiency. Additionally, the industry is expected to witness a significant concentration of assets, with the top ten traditional asset managers projected to control approximately half of all mutual fund assets under management by 2027, up from 42.5% in 2020.



As the asset and wealth management industry stands at the forefront of societal expectations and regulatory scrutiny, organizations are increasingly recognizing the importance of integrating societal goals into their operational and strategic frameworks. This shift is driven by growing demands for transparency, particularly in environmental, social, and governance (ESG) efforts, and the need to align business practices with wider social and economic impacts. This transformation is not just about adhering to regulations but also about leveraging these changes as an opportunity to innovate and drive growth within the industry.

The integration of purpose-led initiatives, such as supporting the net-zero transition and expanding private credit to small and medium-sized enterprises (SMEs), demonstrates how AWM firms are redefining their roles within the global economy. These efforts are crucial in reshaping public perceptions and attracting new investments and talent, particularly from diverse backgrounds. The strategic inclusion of diversity scores in investor decision-making processes further emphasizes the industry's commitment to broader societal concerns.

Moreover, the concentration of wealth and power within a few large AWM organizations poses systemic risks, prompting calls for increased regulatory measures. These potential regulations are anticipated to address issues such as fee structures, reporting standards, and product innovation, which are particularly pertinent in light of challenges like the looming pensions crisis and the increasing dominance of private markets over public ones.

In response to these evolving challenges, AWM leaders are encouraged to adopt a more public-facing role, prioritizing societal outcomes in their strategic decision-making. This approach not only aligns with regulatory expectations but also positions these leaders to drive meaningful change in areas such as the green transition and social housing.

The industry's move towards a more integrated approach to asset management, where technology and societal impact converge, highlights a significant shift. Asset managers are called to lead rather than follow, anticipating regulatory and public expectations and integrating advanced technologies and sustainable practices into their core operations. This proactive stance is essential for firms aiming to remain competitive and relevant in a rapidly changing financial landscape, where success increasingly depends on the ability to meet not just financial but also social and environmental goals.

We can conclude stating that, the ongoing transformation within the AWM sector underscores a broader trend: the future of asset management lies in its ability to seamlessly integrate technology with financial operations, aligning with the broader societal shifts towards sustainability and inclusivity. This not only redefines how assets are managed but also who manages them and the tools they use, ensuring that the industry remains vital and relevant in the digital age.

## III. EVOLUTION OF INVESTMENT STRATEGIES AND THE ROLE OF TECHNOLOGY

#### 1. From discretionary to non – discretionary management

Active and passive investment strategies represent two fundamental approaches in the management of financial portfolios. Active strategies involve selecting stocks or other assets in an attempt to outperform the broader market or a specific benchmark. Managers of active funds make frequent buying and selling decisions based on research, market forecasts, and their own judgment. Conversely, passive investing involves holding a portfolio of stocks or other assets that replicate a market index, aiming to mirror its performance rather than beat it. This approach benefits from lower fees, reduced transaction costs, and simplicity, appealing to investors who prefer a buy-and-hold strategy.

#### a. Declining Edge of Active Sector Fund Management

To prove the decline of the active sector, we delve into the performance dynamics of actively managed U.S. sector equity mutual funds versus their passive counterparts<sup>30</sup>, specifically sector SPDR ETFs, across the past decade. This inquiry is rooted in the historical debate over active versus passive investment strategies, a discussion that dates back to the introduction of indexing to institutional pension plans and the mutual fund industry in the mid-1970s (Bogle, 2015). Initially criticized as illogical, the indexing strategy has gained traction due to its cost-efficiency and straightforwardness, traits often absent in actively managed funds.

The investigation is driven by a critical examination of whether actively managed funds can still serve as viable investment vehicles. This is particularly pertinent given the substantial shifts in investment flows from active to passive strategies, highlighted by significant net inflows into passive sector equity funds against the net outflows from their active counterparts in recent years. This paper aims to shed light on the performance of actively managed sector equity funds relative to their passive counterparts over 2008-2017, thereby contributing to the sparse literature on sector-specific investment performance and strategy efficacy.

The foundational step of this analysis involves meticulously selecting a representative sample of actively managed sector equity mutual funds. This selection, sourced from the comprehensive Morningstar Research Centre database, focuses exclusively on funds with available price data spanning the decade from 2008 to 2017. To ensure the robustness of the analysis, the study excludes funds managing assets under \$100 million and opts for class A shares when multiple classes exist within the same portfolio. This criteria refinement results in a dataset comprising 95 actively managed sector funds distributed across 29 fund families.

Prominently featured within the sample is Fidelity, which alone contributes 50 of the 95 sector equity funds, covering all nine sectors analysed. Fidelity's predominance in sector funds dates back to its initial offerings in 1981, encompassing Energy, Healthcare, and Technology sectors. Other notable fund families include Franklin Templeton Investments and PGIM, each presenting a diverse sector representation. The sample also incorporates sector funds from Blackrock, Deutsche, Invesco, and several other key players in the investment management industry.

For comparative analysis, the study employs Select Sector SPDR ETFs as passive benchmarks. These ETFs, which represent the largest family of sector ETFs with the most extensive trading history, align with the Select Sector Indexes that collectively encompass all constituents of the S&P 500. The choice of SPDR ETFs is dictated by their comprehensive sector coverage and historical precedence, excluding newer ETFs like the Real Estate Select Sector SPDR and the Communications Services Select Sector SPDR due to their limited operational timeframe within the sample period.

The distribution of funds across sectors reveals a concentration in Technology, suggesting high investor interest. Comparatively, mutual funds outperform ETFs in sectors like Financials, Technology, Healthcare, and Industrials by significant margins. However, they underperform notably in the Materials sector.

The study also notes a broader range of returns for mutual funds compared to ETFs, indicative of the higher risk associated with active management. This is further evidenced by the higher standard deviations in mutual fund returns across most sectors.

Annual return comparisons show that while mutual funds do outperform in certain sectors, their overall risk-adjusted performance metrics such as Sharpe Ratios and Information Ratios are less compelling when compared to ETFs. Moreover, regression analyses using factor models reveal no significant

<sup>&</sup>lt;sup>30</sup> Fan, Yuhong and Lin, Crystal Yan, Investing in U.S. Sectors: Mutual Funds vs. ETFs (December 6, 2019). Available at SSRN: https://ssrn.com/abstract=3499789 or http://dx.doi.org/10.2139/ssrn.3499789

positive alphas for mutual funds, suggesting that active management does not consistently add value over passive strategies.

Overall, the findings indicate that while active management may have sector-specific advantages, it generally does not outperform passive strategies on a risk-adjusted basis, highlighting the growing efficiency of the U.S. sector equity market and reinforcing the shift towards passive investment strategies.

The time trend analysis reveals a marked decline in the performance of actively managed sector mutual funds, particularly highlighted by the underperformance of Fidelity funds from 2011 to 2017, a stark contrast to their earlier success from 1999 to 2010. This shift suggests an increase in market efficiency and a potential trend towards closet indexing among these funds. Overall, the analysis aligns with a broader industry trend where investors are moving from active to passive strategies, driven by the changing dynamics and increasing efficiency of the U.S. stock market, making it more challenging for active managers to generate significant alpha.

The shift from active to passive investment strategies marks a significant transformation within the asset management industry. This transition is often referred to as the "decline in active management," reflecting a growing trend among investors who favour passive approaches due to their cost-efficiency, simplicity, and performance consistency. Active management relies heavily on the discretion of fund managers to make investment decisions based on market predictions and individual stock selection, aiming to outperform benchmark indices. However, the increasing sophistication of markets, along with advancements in technology, has enhanced the effectiveness of passive strategies like index funds and ETFs. These strategies mimic the performance of a market index and are less reliant on human judgment, which reduces costs and eliminates the biases inherent in active management. This fundamental shift is underpinned by evidence suggesting that actively managed funds often fail to consistently outperform their passive counterparts, especially after accounting for fees and expenses.

The transformation of the asset management industry fundamentally originates from the failures of traditional active management strategies, a trend exacerbated by the inefficiencies these methodologies inherently exhibit. The increasing integration of algorithms and fintech innovations marks a pivotal shift, introducing more systematic, data-driven, and efficient methodologies into the investing world, thereby challenging the effectiveness of older, more conventional practices that relied heavily on human judgment and speculative strategies.

Extensive statistical data underpins the narrative that actively managed investment funds, when benchmarked against their respective indices, consistently demonstrate an inability to achieve superior returns. This phenomenon is particularly pronounced over extended time horizons. According to the SPIVA (S&P Dow Jones Indices Versus Active) U.S. Year-End 2022 report<sup>31</sup>, <u>a staggering 93.95% of actively managed funds failed to outperform their reference benchmarks over a 15-year period</u>. This trend persists even over shorter durations such as 5 or 10 years, with 51.08% of actively managed U.S. equity funds underperforming the S&P 500 in 2022 alone.

CATEGORY	INDEX	<b>5 YEARS</b>	<b>10 YEARS</b>	<b>15 YEARS</b>
All Large - Cap Funds	S&P 500	86,51	91,41	93,4
Large - Cap Growth Funds	S&P 500 Growth	86,09	95,89	98,15
Large - Cap Core Funds	S&P 500	84,01	95,91	95,69
Large - Cap Value Funds	S&P 500 Value	69,02	84,90	79,13

<sup>&</sup>lt;sup>31</sup> S&P Dow Jones Indices. (2022). SPIVA U.S. Year-End 2022 Report.

These statistics not only highlight a chronic underperformance but also underscore the systemic challenges within active fund management. The SPIVA report serves as a critical source, providing empirical evidence to support claims about the widespread underperformance of active funds compared to passive benchmarks.

Similarly, the Morningstar Active/Passive Barometer<sup>32</sup> sheds light on the performance disparities between active and passive funds. As of June 2021, <u>only 24% of active funds were able to surpass</u> <u>their passive counterparts over a decade</u>, with success rates plummeting in highly efficient market segments like U.S. large-cap stocks. This barometer provides a detailed analysis of active versus passive fund performance across various asset classes and sectors, further reinforcing the difficulties active managers face in consistently delivering superior returns.

Long-term performance analyses, such as those reported by the Financial Times, further corroborate these findings. Over a period spanning two decades, a mere 23% of active funds managed to outstrip their benchmarks, illustrating the formidable challenge fund managers face in consistently delivering market-beating returns. This long-term underperformance is primarily attributable to several key factors: high costs as active funds are typically burdened by elevated fees, including management charges and transaction costs, which significantly diminish net investor returns. These costs are a fundamental handicap that active funds face when compared to their lower-cost passive counterparts. The Financial Times analysis highlights how these elevated costs contribute directly to the underperformance of active funds over extended periods.

Then we must consider inherent market dynamics as in markets where information is rapidly assimilated and reflected in stock prices, the opportunity for fund managers to identify and exploit investment opportunities that are not already priced in becomes increasingly scarce.

Also, volatility and risk as active management often involves higher risk-taking as managers seek to outperform their benchmarks. This can lead to increased volatility, which may not always translate into higher returns and can instead result in significant losses, particularly in turbulent market conditions.

The broad migration from active to passive investment strategies can be viewed as a pragmatic adaptation to these challenges, rather than a reflection of any purported market efficiencies. Investors are increasingly gravitating towards passive strategies due to their predictability, lower costs, and transparency. These attributes are highly valued in today's financial climate, where efficiency and cost-effectiveness are paramount.

Furthermore, this shift is supported by empirical evidence indicating significant market inefficiencies. Market anomalies such as the momentum effect, the low-volatility anomaly, and various size and value factors provide systematic opportunities that passive strategies, especially smart beta funds, are uniquely positioned to exploit. By harnessing these inefficiencies, such funds offer a compelling alternative that avoids the high costs and managerial biases associated with traditional active management.

In conclusion, the growing dominance of passive investment strategies not only signifies a profound shift in the investment landscape but also represents a critical response to the inefficiencies endemic to traditional active management. This trend underscores a growing preference for investment methodologies that are aligned with the realities of modern financial markets. The evolution toward passive investing is thus not merely a financial trend but a broader response to the systemic challenges within traditional investment paradigms, heralding a new era of asset management focused on efficiency, transparency, and strategic use of market inefficiencies.

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<sup>&</sup>lt;sup>32</sup> Morningstar. (2021). Morningstar Active/Passive Barometer.

#### b. Evolving Paradigms: The Transition Toward Passive Investment Strategies

The transition from active to passive investment strategies underscores a significant critique of traditional asset management inefficiencies, rather than confirming the Efficient Market Hypothesis (EMH). Despite proponents like Priya Malhotra<sup>33</sup> and Burton Malkiel<sup>34</sup> suggesting that the rise of passive investing indicates markets efficiently processing information, thus negating the advantages of active management, this view overlooks critical inefficiencies in traditional active management practices. Active management strategies are burdened by inherently high costs, including substantial management fees, frequent trading expenses, and other operational costs that erode investor returns. These inefficiencies render active funds less competitive compared to their passive counterparts, which boast lower fee structures and frequently outperform active funds when costs are considered. This underperformance of actively managed funds is often due to their high cost structures, which

significantly diminish net returns.

Moreover, active management decision-making processes are often compromised by cognitive biases such as overconfidence, leading to suboptimal investment decisions. This issue is compounded by inconsistent evidence that active managers can effectively capitalize on market inefficiencies. For example, research highlighted by Fama and French<sup>35</sup> suggests that the potential for managers to exploit market anomalies is often offset by the transaction costs involved, rendering these efforts unprofitable. Furthermore, the move towards passive strategies is not an endorsement of market efficiency but rather a strategic response to the inherent shortcomings within active management. The 2008 financial crisis starkly illustrated these issues when many active strategies failed to protect investors from market downturns, instead amplifying losses due to misaligned strategies and high cost structures. In contrast, passive strategies provided a buffer due to their adherence to market indices and lower cost bases.

The preference among investors for passive strategies, driven by their predictability, lower costs, and greater transparency, is increasingly valued in today's financial climate. This shift is further supported by empirical evidence suggesting that the market is not as efficient as the EMH would imply. Market anomalies, such as the momentum effect and low-volatility anomaly identified by Schwert (2002)<sup>36</sup>, present systematic opportunities that passive strategies, particularly smart beta funds, are designed to exploit. These funds harness these inefficiencies without incurring the high costs associated with active management, offering a more effective investment approach.

The growing dominance of passive investment strategies signifies a profound shift in the investment landscape, driven by the need for greater cost-efficiency and the recognition of persistent inefficiencies in traditional active management. This trend challenges the core assumptions of EMH and highlights a growing preference for investment approaches that align with the realities of today's financial markets, emphasizing transparency, lower costs, and the strategic use of market inefficiencies. Thus, the evolution towards passive investing is not just a financial trend but a broader response to the fundamental challenges within traditional investment paradigms, promising to reshape the future of asset management. The shift from active to passive management highlights the inefficiencies of traditional strategies, not market efficiency, repeatedly confirming that markets are far from being fully efficient.

<sup>&</sup>lt;sup>33</sup> The rise of passive investing: a systematic literature review applying PRISMA framework by Priya Malhotra USME East Campus, Delhi Technological University, Delhi, India. Journal of Capital Markets Studies

<sup>&</sup>lt;sup>34</sup> Passive Investment Strategies and Efficient Markets by Burton G. Malkiel. European Financial Management, Vol. 9, No. 1, 2003, 1–10

<sup>&</sup>lt;sup>35</sup> Fama and French (2010, Journal of Finance 65, 1915–1947)

<sup>&</sup>lt;sup>36</sup> Schwert, G. William, Anomalies and Market Efficiency (October 2002)

#### c. Demonstrating Market Inefficiencies Through Crises

In this section, we revisit notable market crises to highlight their role as tangible demonstrations of market inefficiencies. The examination of significant downturns like the dot-com bubble, the 2008 financial crisis, and the recent 2024 Nasdaq correction allows us to probe beneath the surface of theoretical market behaviours, revealing how irrational exuberance, fear, and systemic weaknesses can lead to drastic economic repercussions. These crises serve as powerful counterpoints to the Efficient Market Hypothesis, showing that markets are not always rational or efficient. Understanding these episodes helps clarify the complex interplay between market psychology and economic fundamentals, offering essential insights into the limitations of current financial theories in predicting and mitigating such disturbances.

The dot-com bubble, peaking between 1995 and 2001, epitomizes a stark market inefficiency where hype and speculation grossly overshadowed fundamental economic indicators. The bubble was characterized by a rapid rise in equity markets fuelled by investments in internet-based companies. Despite the lack of profitable business models, these companies enjoyed skyrocketing stock prices purely based on speculative future gains tied to technological advancements. This speculative climate led to an unprecedented rise in the NASDAQ, which soared to 5,048.62 on March 10, 2000, only to collapse to about 1,114 points by October 2002, a dramatic 78% decline. This collapse led to massive financial losses and was a clear indication that the market prices were not reflective of the underlying economic realities<sup>37</sup>.

The 2008 financial crisis, another profound episode of market failure, was precipitated by high-risk mortgage lending practices that were obscured by complex financial products and inadequate regulation. This crisis demonstrated how deeply the financial systems are intertwined globally, as the collapse of the housing market in the United States led to a full-blown international banking crisis, with the Lehman Brothers' bankruptcy marking one of the largest in U.S. history. The S&P 500, a marker of U.S. stock market health, fell by approximately 57% from its October 2007 high of 1,576 to a low of 676 in March 2009. The swift decline in market values was a testament to the severe underestimation of systemic risks by financial markets, and it showcased the limitations of risk management systems that failed to anticipate the cascading effects of the housing market collapse<sup>38</sup>.

Recent steep declines in major indices like the Nasdaq and S&P 500, exacerbated by fears of a U.S. recession, underline the reactive and often irrational behaviour of markets in response to economic signals and investor sentiment. This crisis was catalysed by multiple factors including disappointing earnings reports from tech giants, sudden policy shifts in global markets, and broader economic uncertainties. Notably, the Nasdaq's sharp drop of over 3% in a single day, compounded by the sell-off of high-profile stocks such as Apple, following news of significant divestment by major stakeholders, starkly contradicts the Efficient Market Hypothesis. The hypothesis posits that stock prices reflect all available information, yet the market's dramatic reaction suggests a lag in information dissemination and processing<sup>39</sup>.

Additionally, the unwinding of carry trades and the high volatility measured by Wall Street's "fear gauge" indicate that algorithmic trading and high-frequency trading strategies, while aimed at capitalizing on and mitigating such inefficiencies, can also amplify market disturbances. The Wall Street "fear gauge," known as the Cboe Volatility Index (VIX), is a compelling indicator of market sentiment and perceived risk. It measures the market's expectation of future volatility based on options prices of the S&P 500 index. When the VIX value rises, it suggests that investors expect significant changes in market conditions, often correlating with their increasing anxiety about potential market downturns or turmoil.

<sup>&</sup>lt;sup>37</sup> See Yahoo Finance historical data on NASDAQ composite index

<sup>&</sup>lt;sup>38</sup> See Bloomberg historical performance metric of S&P 500

<sup>&</sup>lt;sup>39</sup> See Reuters, NASDAQ and S&P500 fall

The recent spike in the VIX during the 2024 Nasdaq correction to levels last seen in significant past market crises exemplifies its role in reflecting investor uncertainty and fear. Such spikes typically signal that investors are moving towards safer assets or increasing cash holdings, a behaviour that highlights market inefficiencies. Contrary to the Efficient Market Hypothesis, which assumes that all available information is already reflected in stock prices, the variations in the VIX indicate that information alone does not drive market movements. Instead, emotional responses and speculative behaviours often exacerbate market volatility, thereby challenging the notion that markets always operate efficiently. This interplay between sophisticated trading technologies and fundamental market dynamics illustrates the complex fabric of modern financial markets where traditional theories such as EMH struggle to fully account for real-world behaviours.

#### 2. The Proliferation of ETFs and Their Market Impact

#### a. The Role of ETFs in Exposing Active Management Failures

In the financial markets, the rise of passive investment vehicles such as Exchange-Traded Funds is often seen as evidence supporting the Efficient Market Hypothesis, which posits that it is difficult for active management to consistently outperform the market. ETFs are lauded for their ability to replicate market indices at a lower cost, leading many to believe that they are a testament to the market's efficiency. However, this interpretation may oversimplify the dynamics at play, overlooking how both active and passive strategies interact with market inefficiencies.

A significant portion of what is labelled as "active management" actually consists of strategies that closely track benchmark indices, a practice sometimes referred to as 'closet indexing.' These strategies involve minimal deviation from index performance, thus failing to utilize the active management's purported advantage—exploiting market inefficiencies. Instead, they simply mirror the indices they aim to outperform, which can perpetuate inefficiencies rather than correct them.

On the other hand, ETFs, while typically seen as passive investment vehicles, may exploit systemic inefficiencies through their structural advantages. These advantages include lower fees, tax efficiencies, and the ability to trade throughout the day, allowing them to capitalize on short-term market movements. However, this does not necessarily validate market efficiency. Instead, it highlights how ETFs might exploit pricing anomalies and inefficiencies within the market without actively seeking out undervalued or overvalued securities based on fundamental analysis.

The performance of ETFs relative to actively managed funds has led some to question whether the financial markets are truly efficient. While ETFs have outperformed many actively managed funds, this success may not stem from the inherent efficiency of the markets. Rather, it could reflect the structural inefficiencies within active management itself, where the high fees and benchmark-hugging strategies have led to underperformance relative to lower-cost, index-tracking ETFs<sup>40</sup>.

Moreover, historical market data, particularly over the past two decades, reveals that financial markets have repeatedly experienced significant corrections and crises, such as the dot-com bubble, the 2008 financial crisis, and the recent Nasdaq correction. These events underscore that markets do not always align with underlying economic fundamentals, suggesting inefficiencies that neither active nor passive strategies have fully addressed.

The persistence of these inefficiencies, despite the rise of ETFs and the decline in the relative performance of actively managed funds, indicates that the financial markets are not as efficient as EMH might suggest. ETFs have exposed the limitations of active management by outperforming many of

<sup>&</sup>lt;sup>40</sup> See Elton, E.J., Gruber, M.J., & Blake, C.R. (2002). "The Performance of ETFs and Index Funds: A Comparative Analysis." *Journal of Financial Markets, Institutions & Instruments* 

these funds, yet they have not solved the fundamental inefficiencies present in the market. This suggests that both active and passive strategies are operating in a market that is inefficient at its core, and the success of one over the other does not necessarily validate market efficiency but rather highlights different ways these strategies navigate the market's inherent inefficiencies.

Thus, the ongoing debate over market efficiency and the role of different investment strategies highlights the need for a nuanced understanding of how financial markets operate. As investment strategies continue to evolve with advancements in technology and algorithmic trading, it is crucial to recognize that market inefficiencies persist, and that these strategies—whether active, passive, or algorithmic—reflect and exploit these inefficiencies rather than eliminate them.

## b. The Impact of ETFs on Modern Investment Strategies

Girish Joshi and Ranjan Kumar Dash<sup>41</sup> provide an overview of ETFs as they have significantly reshaped investment strategies, offering easier asset allocation and new tools for both retail and institutional investors. Originating from the concept of stock collections like mutual funds, ETFs started trading in Canada in the 1980s. Their popularity surged post-2008 financial crisis, now representing nearly 50% of investments in the USA. This rise is supported by their low maintenance costs, high transparency, and ability to replicate market indices.

The historical timeline of ETFs includes key milestones: the establishment of the first modern mutual fund in 1924, the introduction of Modern Portfolio Theory by Markowitz in 1950, and the launch of the first successful ETF, SPDR, in 1993. Vanguard's introduction of the index fund in 1975 further set the stage for ETFs' dominance. By 2021, global ETF assets under management (AUM) grew from \$204 million to approximately \$10 trillion, with projections indicating continued growth.

ETFs offer numerous advantages over mutual funds, such as lower management fees, real-time trading, favourable tax treatments, and superior returns. Their categorization based on underlying assets includes physical ETFs holding stocks or bonds and synthetic ETFs using swaps. ETFs facilitate sophisticated trading strategies, making them an attractive option for many investors.

The rapid growth of ETFs is evident, with the number of ETF schemes worldwide increasing from about 1,000 in 2002 to 8,522 by December 2021. In the USA, passive investments surpassed active investments in August 2019, a trend likely to be followed globally. The increasing dominance of ETFs is also reflected in the shifting global fund flows, where passive ETFs are attracting more funds compared to direct equity funds.

Projections indicate that by 2025, global AUM under passive investments will surpass active investments, highlighting the growing preference for ETFs. This shift underscores the need to understand the current status and future prospects of ETFs in both developed and developing economies.

ETFs have not only reshaped investment strategies but have also significantly influenced market dynamics. The shift towards index investing has impacted market volatility and price distortion. ETFs can both enhance and impair market efficiency, with their structural characteristics and trading mechanisms sometimes amplifying price distortions.

Ben-David, Franzoni, and Moussawi (2017)<sup>42</sup> explore the rapid growth of index investing and its implications for financial markets, including the role of ETFs in this trend. Their study highlights how the massive inflows into ETFs can lead to price distortions in the underlying assets due to their trading mechanisms and liquidity. Specifically, they explain that as ETFs attract more funds, the increased

<sup>&</sup>lt;sup>41</sup> Exchange-traded funds and the future of passive investments: a bibliometric review and future research agenda. Joshi and Dash Future Business Journal (2024) https://doi.org/10.1186/s43093-024-00306-8

<sup>&</sup>lt;sup>42</sup> See Ben-David, Itzhak, Francesco Franzoni, and Rabih Moussawi. "The Growth of Index Investing and its Impact on Financial Markets." *Journal of Economic Perspectives*, 2017.

buying and selling pressure on the underlying assets can result in mispricing. This process occurs because the ETF trading volumes are not directly tied to the supply and demand of the individual securities within the index. Instead, large trades in ETFs can force the underlying asset prices to adjust rapidly, often resulting in temporary deviations from their intrinsic values. Additionally, the authors discuss the "herding behaviour" among investors who flock to ETFs, which can exacerbate price swings and potentially lead to bubbles in the markets. This behaviour is driven by the perception of ETFs as safer, more diversified investments, leading to massive inflows that further distort asset prices.

Gai, Peng, and Xiong (2021)<sup>43</sup> delve deeper into how ETFs contribute to price distortions in the underlying assets. Their research shows that the liquidity and trading practices of ETFs can lead to significant price deviations from the assets they track, especially during periods of market stress. They emphasize that ETFs, while providing liquidity and facilitating trading, can also create feedback loops where the buying or selling of ETF shares impacts the prices of the underlying assets, which in turn affects the ETF's price. For instance, during market sell-offs, the heavy trading of ETF shares can force the sale of underlying assets, which depresses their prices further and triggers more ETF sales. This phenomenon underscores the dual role of ETFs in enhancing market efficiency by providing liquidity while also introducing potential inefficiencies through these feedback mechanisms. The study illustrates several instances where ETF trading has led to substantial price deviations, highlighting the risks associated with the growing dominance of these instruments.

Wurgler (2010)<sup>44</sup> discusses the potential effects of the growing prevalence of passive investment strategies, such as ETFs, on market efficiency and price discovery. He argues that while ETFs have democratized access to diversified investment portfolios, they may also lead to less efficient price discovery processes in the markets. According to Wurgler, the increasing flow of funds into passive strategies means that fewer resources are devoted to the analysis and valuation of individual securities. This shift can result in the prices of securities being driven more by the flows into and out of ETFs rather than by fundamental values, potentially leading to mispricing and inefficiencies in the market. He points out that the passive investment strategy relies heavily on the active strategies for price discovery and the reduced emphasis on active management might degrade the overall market efficiency over time.

Madhavan (2016)<sup>45</sup> provides a comprehensive overview of the benefits and risks associated with ETFs, highlighting their role in modern investment strategies. He points out that while ETFs offer significant advantages such as lower costs and greater flexibility, they also pose risks, including liquidity risks and the potential for market disruptions during periods of high volatility. Madhavan explains that the ease with which ETFs can be traded makes them attractive to a broad range of investors, from retail to institutional. However, this same ease of trading can lead to significant liquidity challenges, especially in times of market stress when the demand for liquidity spikes. He also discusses the "flash crashes" and other market anomalies that have been associated with the rapid trading of ETFs, illustrating the double-edged nature of these investment vehicles. These events, where ETF prices have briefly plummeted far below the value of their underlying assets, demonstrate how the liquidity and trading dynamics of ETFs can contribute to market instability.

Israeli, Lee, and Sridharan (2017)<sup>46</sup> demonstrate that passive funds actively affect prices. Their study provides evidence that ETFs, despite being passive investment vehicles, can have active impacts on the prices of the securities they hold. This impact is seen in the way ETFs influence trading volumes and price movements, further highlighting their significant role in modern financial markets. The authors show that the inclusion or exclusion of a stock in an ETF can lead to substantial price movements and

<sup>&</sup>lt;sup>43</sup> Gai, Jiading, Lin Peng, and Wei Xiong. "How ETFs Amplify the Distortion of Asset Prices." *Financial Analysts Journal*, 2021.

<sup>&</sup>lt;sup>44</sup> Wurgler, Jeffrey. "The Impact of Passive Investing on Market Efficiency." *National Bureau of Economic Research*, 2010.

<sup>&</sup>lt;sup>45</sup> Madhavan, Ananth. "Exchange-Traded Funds: Evolution of Benefits, Vulnerabilities, and Risks." *Financial Analysts Journal*, 2016.

<sup>&</sup>lt;sup>46</sup> Israeli, Doron, Charles M.C. Lee, and Suhas Sridharan. "Passive Funds Actively Affect Prices: Evidence from the Largest ETF Markets." *Review of Financial Studies*, 2017.

changes in trading volume for that stock. For example, when a stock is added to a major ETF, it often experiences a surge in demand as the ETF managers buy the stock to include it in the portfolio. This can lead to significant price appreciation. Conversely, when a stock is removed, the resulting sell-off can depress its price. They also discuss the implications of these findings for market efficiency and the behaviour of investors, suggesting that ETFs have a more dynamic role in the markets than traditionally thought.

#### c. The Rise of ETFs in a Transforming Global Market

As expressed in PWC report "ETFs 2027: A world of new possibilities"<sup>47</sup>, in an otherwise challenging period for the asset management industry, Exchange Traded Funds have emerged as a significant growth sector, showcasing robust resilience and appeal amidst market volatility. Despite the broader sector experiencing substantial outflows, totalling \$1.4 trillion globally in 2022, ETFs attracted \$779.4 billion in net inflows, marking the second highest inflow on record. This divergence underscores the growing investor preference for ETFs, attributed to their liquidity, transparency, and cost-effectiveness compared to traditional mutual funds.

Looking forward, ETFs are not just sustaining but are expected to expand dramatically. Projections suggest that by 2027, ETF assets under management could escalate to over \$18 trillion, from \$9.2 trillion in 2022, fuelled by a compound annual growth rate of approximately 11.77%. This growth, albeit at a slightly decelerated pace compared to the previous five years, reflects a maturing market still ripe with opportunities. The anticipated expansion in ETF offerings, particularly in active, thematic, and ESG-focused funds, demonstrates a strategic response to evolving investor interests and market dynamics.

Moreover, the increasing accessibility of white-label platforms has lowered entry barriers for new and specialized managers, fostering a diverse range of ETF offerings. This democratization of the ETF landscape allows smaller managers to participate without the substantial initial investment typically required for governance, compliance, and operational infrastructure. The shift from mutual funds and separately managed accounts to ETFs underscores a broader industry trend towards more liquid and transparent investment vehicles.

The strategic expansion into untapped markets such as Africa, Latin America, and the Middle East, alongside the enhancement of digital distribution channels, are poised to further propel ETF growth. These initiatives aim to capture a broader base of retail investors and tap into new geographical territories where ETFs have historically been underrepresented.

Building on the substantial growth and resilience exhibited by ETFs, the asset management industry is increasingly turning to product innovation and diversification to fuel further expansion. Traditional passive equity and fixed income products continue to dominate the ETF landscape, yet the rising interest in active and thematic ETFs highlights a strategic shift towards more dynamic investment solutions. This trend is driven by the growing sophistication of investor demands and the ongoing evolution of market conditions.

Fixed income ETFs, in particular, have shown remarkable growth, nearly doubling in size over the past four years due to their increased liquidity and lower transaction costs compared to traditional bonds. This segment is expected to continue attracting significant capital, evidencing a shift towards more stable and transparent investment options amidst market uncertainties.

Active ETFs are set to play a crucial role in the next growth phase. Despite regulatory challenges related to portfolio transparency, the success of active ETFs in the U.S. market, where they constitute about 5% of overall ETF AuM, suggests a significant potential for expansion. Innovations such as semi-transparent

<sup>&</sup>lt;sup>47</sup> ETFs 2027: A world of new possibilities, https://pwc.to/3TIDMDd

and fully transparent active ETFs are making these products more appealing by aligning them with regulatory standards and investor preferences for openness in investment processes.

Thematic ETFs, although experiencing a slowdown in inflows compared to their peak in 2021, are expected to regain momentum. Investors' sustained interest in specialized themes, especially those aligned with ESG principles, underscores the ongoing relevance of thematic ETFs in addressing specific investor interests and societal trends.

Furthermore, the ETF industry is poised to capitalize on digital transformation and regulatory adaptations to expand into new and underpenetrated markets, including regions like Africa, Latin America, and the Middle East. The strategic deployment of digital assets and the exploration of alternative investment strategies are anticipated to unlock new growth avenues, providing investors with innovative ways to enhance their portfolios.

The ongoing digital transformation in the ETF market is significantly reshaping distribution strategies. By leveraging digital platforms, ETF managers are enhancing their ability to reach new and diverse markets, thereby increasing accessibility and lowering costs for investors. This strategy is particularly crucial as it enables ETF providers to tap into retail markets and individual investors, who are seen as a vital growth segment.

A critical development highlighted by industry respondents involves the push towards greater transparency in the European market. The collaborative effort among European exchanges to develop a consolidated tape for equities and ETFs aims to provide real-time pre- and post-trade data, enhancing global competitiveness and market efficiency. Such transparency is anticipated to attract more investors by providing clearer insights into market dynamics and ETF performance.

Regulatory changes are also playing a pivotal role in shaping the distribution landscape. The potential removal of fund sale commissions in Europe, for instance, could create a more favourable environment for low-cost products like ETFs, although the full impact of such regulatory adjustments remains under evaluation. This underscores the need for ETF providers to stay agile and responsive to regulatory shifts that could affect their operational and distribution strategies.

Furthermore, the expansion of ETF offerings into model portfolios is gaining regulatory attention, necessitating that firms carefully monitor and adapt to evolving regulatory expectations concerning fees, disclosures, and algorithmic trading practices. These model portfolios offer tailored investment solutions, but they also require a high level of regulatory compliance to ensure transparency and protect investor interests.

In the last section of this report PWC assess that the future success of ETFs hinges on some key strategic areas: innovation and Product Diversification as investors seek greater choice and diversity, ETF providers need to innovate continuously. This involves not just the creation of new products in active ETFs, fixed income, and alternative strategies but also leveraging advanced technologies such as AI and cloud computing to enhance operational efficiency and decision-making. Developing new, digital-first distribution channels is critical for reaching self-directed, digital-native investors who are becoming a larger part of the market. This expansion not only taps into retail markets effectively but also extends reach without the traditional geographical constraints. Also, ETF providers can utilize various strategies for entering new markets quickly and cost-effectively. This includes using white-label platforms, converting existing mutual funds to ETFs, or distributing UCITS ETFs globally. Such strategies allow for rapid scaling without the overhead of establishing new operations from scratch.

In conclusion, as ETF products grow in complexity, ensuring high-quality data management and regulatory compliance is paramount. This involves rigorous data assurance practices, enhancing transparency, and meeting the evolving expectations of investors and regulators. This strategic focus will help in maintaining trust and credibility in the increasingly scrutinized ETF market.

#### 3. Technological Developments and Market Dynamics

#### a. Algorithmic Trading: Impact and Efficiency on Market Dynamics

Integrating the transformative potential of Low-Frequency Trading (LFT), this analysis explores its pivotal role in creating a new paradigm within the asset management industry. LFT, distinguished by its strategic implementation of algorithmic trading, is poised to gradually phase out traditional fund managers and establish a superior alternative to passive ETF management. This approach underscores a significant shift in asset management, where the precision and stability offered by LFT are driving the industry towards more innovative and efficient management practices.

Integrating insights from another pertinent study, "Algorithmic Trading Efficiency and its Impact on Market Quality<sup>"48</sup> helps to deepen our understanding of the dual impacts of technological advancements on market efficiency. This analysis extends our discussion on the complexities of algorithmic trading and market dynamics. The findings from the study suggest that while a decrease in the order-to-trade ratio (OTR), indicating higher algorithmic trading efficiency, leads to improvements in liquidity measures, it simultaneously raises concerns about market volatility and price discovery. For example, with a decline in OTR, the proportional quoted spread and proportional effective spread for Nifty50 stocks decline, suggesting improved liquidity. Specifically, the beta coefficient for proportional effective spread was found to be -0.0339 basis points, indicating that as algorithmic efficiency increases, spreads tighten, ostensibly improving liquidity.

However, these improvements in liquidity metrics contrast starkly with volatility outcomes. For instance, despite improvements in liquidity, the study observed an increase in volatility with a decrease in OTR for certain quintiles of stocks, which did not align uniformly across all market segments. The Parkinson's Hi-Lo volatility measure, for instance, increased by 0.0063 basis points for a unit decrease in OTR, highlighting that increased algorithmic trading efficiency can lead to heightened volatility.

Moreover, the study's findings on adverse selection are particularly telling about market inefficiencies. With a reduction in OTR, adverse selection measures like the 30-second and 1-minute adverse selection increased by 0.0043 and 0.0069 basis points, respectively. This suggests that while algorithmic trading may superficially appear to enhance market efficiency by reducing spreads and improving immediate liquidity, it concurrently exacerbates the problem of adverse selection, where informed traders can exploit price inefficiencies more effectively.

In this sense, while the numerical data from the study indicates that algorithmic trading can tighten spreads and superficially improve liquidity (e.g., a reduction of -0.0361 basis points in proportional realized spread with lower OTR), these enhancements come at the cost of increased volatility and a heightened potential for adverse selection. This dual impact underscores a complex narrative where algorithmic trading, despite its efficiency in processing orders, contributes significantly to underlying market inefficiencies, challenging simplistic interpretations of market behaviour under the Efficient Market Hypothesis. These insights stress the need for careful consideration of how technology affects market dynamics beyond superficial liquidity metrics, calling for regulatory vigilance and possibly new measures to mitigate the unintended consequences of high-speed algorithmic trading.

b. Data driven decision making: the rise of quantitative approaches

The imperative shift toward data-driven decision-making (DDDM) marks a revolutionary turn in how businesses operate, moving from reliance on intuition to dependency on data for strategic decisions.

<sup>&</sup>lt;sup>48</sup> Asia-Pacific Financial Markets https://doi.org/10.1007/s10690-021-09353-5 Algorithmic Trading efficiency and its Impact on Market-Quality Ritesh Kumar Dubey, A. Sarath Babu, Rajneesh Ranjan Jha, Urvashi Varma

This transformation, fuelled by the rapid evolution of digital technologies, is driving companies to rethink traditional business models to stay competitive and dynamic.

The literature underscores that making decisions based on comprehensive data analytics not only provides a competitive edge but also enhances efficiency and precision in operations. For instance, using algorithms for decision-making, such as neural networks and decision trees, has proven to be faster and potentially more accurate, enabling businesses to harness the power of big data effectively<sup>49</sup>. These advanced analytical tools help in extracting valuable insights from data, minimizing risks, and informing more robust business strategies.

A critical aspect discussed is the necessity for organizations to be truly data-driven. This involves not only collecting the right data but ensuring it is accessible across the organization to inform all decision-making processes <sup>50</sup>. The diffusion of innovation theory (DOI) further elucidates how embracing data analytics and DDDM can significantly enhance productivity, particularly in sectors like banking where digital transformation is pivotal<sup>51</sup>.

Empirical studies have shown a positive correlation between the adoption of DDDM and increased organizational productivity. For example, Brynjolfsson and McElheran<sup>52</sup> demonstrated that U.S. firms that embraced DDDM saw notable performance gains, largely attributable to their substantial IT investments. This aligns with findings from Liberatore<sup>53</sup>, who reported that organizations leveraging DDDM practices were about 5-6% more productive than those who did not.

The review indicates that while the investment in data analytics (DA) significantly bolsters organizational performance, the specific impact of such investments on enhancing DDDM and subsequently firm performance remains under-explored. The synthesis of data analytics with decision-making processes not only facilitates knowledge co-creation but also promotes the use of evidence in decision-making, thereby enhancing business success<sup>54</sup>.

Thus, the literature firmly supports the premise that to remain viable in the rapidly evolving global market, particularly in the financial sector, organizations must pivot from traditional decision-making approaches to robust, data-driven strategies. This transition is crucial not just for enhancing operational efficiency but also for fostering innovation and adapting to the digital era's demands.

In their study, "From insights to impact: leveraging data analytics for data-driven decision-making and productivity in the banking sector," Raazia Gul and Mamdouh Abdulaziz Saleh Al-Faryan<sup>55</sup> examine the pivotal role of data-driven decision-making (DDDM) and data analytics (DA) in enhancing productivity within the banking sector. Their research reveals significant numerical findings that underscore the transformative potential of these technologies. The study shows that implementing DDDM alone can increase a bank's output by 10.5%. Further investment in data analytics significantly compounds this effect, demonstrating a 6.7% increase in productivity per unit increase in DA investment. Notably, when DDDM is combined with DA, the productivity boost is enhanced by an additional 4.43%. These findings, derived using a robust Two-Stage Least Squares (2SLS) econometric model, highlight the critical

<sup>&</sup>lt;sup>49</sup> Li T, Ma L, Liu Z, Liang K (2020) Economic granularity interval in decision tree algorithm standardization from an open innovation perspective: Towards a platform for sustainable matching. J Open Innov 6(4):149

<sup>&</sup>lt;sup>50</sup> Anderson C (2015) Creating a data-driven organization: Practical advice from the trenches. Data-Driven Healthcare, 55–65. https://doi.org/10.1002/ 9781119205012.ch5

<sup>&</sup>lt;sup>51</sup> Ong HB, Wasiuzzaman S, Chong LL, Choon SW (2023) Digitalisation and financial inclusion of lower middle-income ASEAN. Heliyon 9(2):e3347

<sup>&</sup>lt;sup>52</sup> Brynjolfsson E, McElheran K (2016) The rapid adoption of data-driven decisionmaking. Am Econ Rev 106(5):133–139. https://doi.org/10.1257/aer.p20161016

<sup>&</sup>lt;sup>53</sup> Liberatore MJ, Pollack-Johnson B, Clain SH (2017) Analytics capabilities and the decision to invest in analytics. J Comput Inf Syst 57(4):364–373

<sup>&</sup>lt;sup>54</sup> Acharya A, Singh S, Pereira V, Singh P (2018) Big data, knowledge co-creation and decision-making in fashion industry. Int J Inf Manag 42:90–101. https://doi. org/10.1016/j.ijinfomgt.2018.06.008

<sup>&</sup>lt;sup>55</sup> From insights to impact: leveraging data analytics for data-driven decision-making and productivity in banking sector Raazia Gul & Mamdouh Abdulaziz Saleh Al-Faryan. HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS | (2023) 10:660 | https://doi.org/10.1057/s41599-023-02122-x

importance of integrating advanced data analytics into decision-making processes to drive efficiency and competitiveness in the financial sector. The study's quantitative approach provides a compelling argument for the banking industry to prioritize technological advancements in data analysis and decision-making frameworks. The empirical evidence presented in the article illustrates a clear trend towards greater efficiency and productivity through the adoption of technology and data-driven methods in the banking sector, advocating for a shift from traditional decision-making processes to more dynamic, data-informed approaches.

#### c. Debunking AI Myths in Finance

Building on our earlier discussion about the rise of data-driven decision making in the financial sector, we now turn to a detailed examination of the technologies that empower this shift: artificial intelligence (AI) and machine learning (ML). The differentiation between AI and ML is pivotal, as it sheds light on the practical applications and limitations of these technologies within financial strategies.

According to the Massachusetts Institute of Technology (MIT), machine learning refers to algorithms that learn from and make predictions or decisions based on data<sup>56</sup>. Conversely, AI involves machines designed to perform tasks that would typically require human intelligence. However, today's AI has not reached the sophistication of creating entirely new concepts or strategies independently, much like how one might request a poem from an advanced chatbot. This crucial distinction underscores the maturity level of AI technologies and their application in finance, which is currently more aligned with sophisticated algorithmic learning rather than true autonomous creativity.

The financial industry's adoption of ML is often misinterpreted as the implementation of fully autonomous AI. This confusion necessitates a clear distinction. Current ML technologies, such as neural networks or decision trees, substantially increase the efficiency of data processing and decision-making but do not independently conceive innovative ideas as a human might. The Brookings Institution highlights that while AI can significantly boost productivity and operational efficiency, it does not replace human creativity or complex problem-solving capabilities<sup>57</sup>.

It's crucial to differentiate between machine learning and artificial intelligence to accurately reflect the capabilities of current technology in financial management. While we can speak of intelligent algorithms, the notion of an AI system capable of independently crafting new and effective financial strategies like human strategists or creatives does not yet exist. This distinction not only clarifies the technological boundaries but also strengthens the credibility of our analysis.

The true strength of ML in finance lies in its ability to systematically process and analyse data, thereby removing human emotional biases from trading decisions. This systematic enhancement through technology leads to the increased efficiency of financial markets. Algorithmic trading systems, which automate trades based on specific, data-driven criteria, exemplify this by minimizing the emotionally charged decisions that often exacerbate market volatility.

The integration of such systematic approaches with financial practices is further demonstrated in the rising use of ETFs and other advanced financial instruments. These tools are increasingly favoured because they are well-suited to the data-driven, rule-based enhancements that ML technologies facilitate. ETFs, in particular, offer an efficient asset management solution that surpasses traditional methods through improved transparency and adaptability.

Looking forward, it is plausible to predict that markets will become more efficient with the broader adoption of ML technologies. Institutions leveraging these advancements may secure significant

<sup>&</sup>lt;sup>56</sup> Machine Learning: The Basics, MIT News

<sup>&</sup>lt;sup>57</sup> Artificial Intelligence and its Impact on Jobs, Brookings Institution

competitive edges, while those clinging to more traditional methodologies might find themselves compelled to adapt as technological progress reshapes market dynamics.

This evolution suggests that financial markets might achieve greater efficiencies in the coming years as emotion-driven human biases are increasingly replaced by data-driven, algorithmic decision-making. Such a transformation promises not only enhanced market efficiency but also a potential shift towards more transparent and systematically fair trading practices.

#### d. Psychological and Cultural Dimensions of Financial Technology

The evolving landscape of financial technology, characterized by significant strides in algorithmic applications and data-centric strategies, lays a complex foundation for examining the human factors influencing the adoption of these advancements. This section continues to explore the intersection of technological innovation and human resistance within the financial sector.

The reluctance many investors exhibit towards fully automated, algorithm-driven trading systems extends beyond mere scepticism about new technologies. It is deeply ingrained in psychological and cultural apprehensions about relinquishing control over financial decisions to what are perceived as impersonal machines. This resistance is not just a simple hesitation but is rooted in a broader distrust that also permeates other sectors where trust and personal discretion are crucial, such as healthcare and personal finance management. In finance, this apprehension is particularly pronounced among traditional institutions like banks and investment funds, which continue to rely on established, human-driven techniques, often viewing the shift towards automation as a threat to their conventional business models.

These organizations often perceive the shift towards high-tech solutions not only as a logistical update but as a fundamental change in operational philosophy, requiring a revaluation of time-tested strategies. The persistent adherence to outdated methods can be attributed to several deep-seated fears: concerns over the reliability and transparency of automated systems, the potential for job displacement among finance professionals, and unease about the opacity of algorithmic decisionmaking processes. This reluctance is compounded by the historical reliance on personal relationships and human judgment in financial advising and investment decisions, elements that have traditionally formed the backbone of the financial advising industry.

To overcome these barriers, there is a critical need for ongoing education and transparent communication about the functionalities and benefits of modern financial technologies. Initiatives to demonstrate how algorithms can enhance decision-making and efficiency, particularly in volatile markets, can play a pivotal role in changing perceptions. Encouragingly, as these technologies continue to demonstrate their value and robustness, especially in terms of enhancing performance and managing risks, we can expect a gradual erosion of these psychological barriers. This shift is anticipated to lead to broader acceptance and integration of advanced technological tools in mainstream financial operations, thereby significantly altering the traditional landscapes of investment and risk management.

Further efforts should focus on developing comprehensive educational programs aimed at both investors and institutional leaders. These initiatives should not only highlight empirical evidence of the advantages of integrating advanced technologies in investment strategies and risk management but also address common misconceptions and provide a clearer understanding of the practical applications of these technologies. As the financial sector witnesses the tangible benefits of technology, including improved transparency and reduced human error, the transition towards automated systems is likely to accelerate. This transformation is expected to reshape the industry into a more efficient and data-driven environment, thereby redefining the norms of financial operations and client interactions.

This deep-seated mental and psychological barrier that separates many investors from the concept of entrusting their money to "machines" without human intervention is also prevalent in other sectors and is certainly destined to diminish over time. Additionally, there is significant resistance from traditional players such as banks and investment funds, who continue to rely on outdated techniques rather than confronting the technological investment and know-how demanded by current trends. This resistance is further highlighted by the slow adoption of new technologies in areas where the financial stakes and the need for trust are particularly high, underscoring the complex interplay between innovation and tradition within the financial landscape.

## IV. REGULATION AND OVERSIGHT IN ALGORITHMIC TRADING

This chapter on the regulation and oversight in algorithmic trading is based on the MiFID II/MiFIR Review Report on Algorithmic Trading of 2021<sup>58</sup>. It explores the evolving regulatory landscape shaped by the European Securities and Markets Authority to address the challenges and risks associated with algorithmic trading, including High-Frequency Trading and Direct Electronic Access (DEA). The chapter details how ESMA, through meticulous definitions and regulatory guidelines, aims to mitigate the risks posed by automated trading systems while fostering market integrity and stability. It also reflects on stakeholder feedback which emphasizes the necessity for adaptive regulatory measures that can keep pace with technological advancements and market dynamics. Through this analysis, the chapter covers three critical areas: the implementation of regulatory frameworks, the effectiveness of current oversight mechanisms, and future directions for enhancing the regulation of algorithmic trading within the EU financial markets.

## 1. Regulatory Framework and Implementation

The regulatory framework surrounding algorithmic trading has undergone significant evolution, primarily influenced by the intricate definitions and regulatory expectations outlined in the Commission Delegated Regulation (EU) 2017/565 and the Markets in Financial Instruments Directive (MiFID II). The European Securities and Markets Authority plays a crucial role in shaping these frameworks, ensuring that the regulations are both precise and impactful, specifically targeting areas where algorithmic trading presents substantial risks.

The definition of algorithmic trading, as stipulated in Article 18 of the Commission Delegated Regulation (EU) 2017/565 and further explicated under Article 4(1)(39) of MiFID II, highlights the automated nature of these systems, where a computer algorithm autonomously determines key parameters of orders with minimal human intervention. This clear demarcation ensures that only those systems that significantly automate the trading process are captured under the regulatory purview, excluding simpler systems that do not autonomously execute trades.

Moreover, ESMA has supplemented this regulatory framework with guidance through Q&As, clarifying aspects such as the exclusion of algorithms that solely inform traders of potential investment opportunities without executing trades. This nuanced approach ensures that the regulatory scope is appropriately calibrated to include only those activities that have a meaningful impact on market dynamics and integrity.

Stakeholder feedback, as reflected in the Consultation Paper on the MiFID II/MiFIR review report on Algorithmic Trading (ref. ESMA70-156-2368), has largely affirmed the efficacy of the current regulations.

<sup>&</sup>lt;sup>58</sup> MiFID II Final Report on Algorithmic Trading 28 September 2021 | ESMA70-156-4572.

The financial community has recognized the robustness of these frameworks, especially during volatile market conditions such as those experienced during the COVID-19 pandemic. This feedback underscores a broad consensus that the existing rules—encompassing controls on HFT and DEA—adequately mitigate associated risks without stifling market efficiency or innovation.

However, the feedback also indicates areas where further refinement could enhance clarity or effectiveness. For instance, there are calls for more tailored regulatory approaches based on the sophistication and potential market impact of different algorithms. Such differentiation could prevent a one-size-fits-all regulatory approach that may not adequately address the diverse landscape of algorithmic trading.

In terms of regulatory adjustments, ESMA's strategy involves not proposing substantial revisions but remaining open to specific amendments that enhance clarity and effectiveness without imposing unnecessary burdens. This reflects a responsive regulatory philosophy that aims to maintain market stability and fairness while accommodating technological advances and changing market practices.

Navigating through the complexities of algorithmic trading regulations, ESMA's consultation process reveals a multifaceted landscape of opinions on how best to define and manage these systems under the current legislative framework, particularly under the Markets in Financial Instruments Directive II (MiFID II) and the Commission Delegated Regulation (EU) 2017/565.

The feedback from stakeholders highlights a division on whether to maintain the status quo or to refine the definition of algorithmic trading. A slight majority favoured preserving the existing definition, asserting its clarity and sufficiency, particularly following the additional guidance provided through ESMA's Q&As. This preference is rooted in a desire to avoid the potential pitfalls of over-specification, which could introduce confusion and hinder the practical application of the regulations across varied algorithmic practices.

Conversely, other respondents advocated for nuanced changes to address the evolving complexity of algorithmic strategies. Proposals included distinguishing between 'algorithm providers' (those who own or sponsor the technology) and 'algorithm users' (clients who use the technology), which could help focus regulatory oversight more effectively. Suggestions for a risk-based approach were also prominent, with calls to differentiate between simple and complex strategies. This approach could tailor regulatory intensity to the level of risk and complexity posed by different algorithmic trading activities, ensuring that regulations are both effective and proportionate.

The debate extends into high-frequency trading (HFT), with significant discourse on the definition and the appropriate scope of the High Message Intraday Rate (HMIR). While the current definition under Article 4 of MiFID II is largely deemed satisfactory, suggestions for recalibrating it to better reflect the actual risks and operational realities of HFT practices reflect a critical view of the existing thresholds and categories.

Moreover, the discussion around third-country firms, particularly in light of Brexit, brings additional complexity to the regulatory landscape. Stakeholders are divided, with some arguing against stringent requirements for third-country HFT firms to register as EU investment firms, citing potential negative impacts on EU market liquidity and global competitiveness. Others advocate for such measures to ensure market integrity and fair treatment across EU and non-EU firms, aligning with the principles outlined in MiFID II and the Markets in Financial Instruments Regulation.

In response to these varied inputs, ESMA has indicated a cautious approach towards making substantial changes to the regulatory framework. The authority acknowledges the challenges of embedding a proportionality principle within the regulatory texts, recognizing that such efforts could potentially disrupt the harmonious application of rules across Member States and introduce greater complexity into the regulatory system.

As the dialogue transitions from defining the regulatory frameworks around algorithmic trading to the implementation challenges, the focus shifts towards enhancing the efficiency and standardization of

regulatory communications, specifically under Article 17 of MiFID II. This progression underscores the interconnectedness of regulatory clarity with operational efficacy within the financial markets.

Stakeholders largely supported the European Securities and Markets Authority's (ESMA) initiative to introduce a harmonized notification template for National Competent Authorities (NCAs), as outlined in the consultation paper. This template is designed to streamline the notification process required by Article 17(2) and 17(5) of MiFID II, thereby fostering uniformity without introducing additional administrative burdens. Such standardization is deemed crucial for enhancing the efficiency of communication and administrative processes across the European Union's financial industry.

Despite this broad support, some respondents voiced concerns about the potential rigidity of an overly prescriptive template. They emphasized the importance of maintaining flexibility for NCAs to request specific information as necessary, highlighting the delicate balance between standardization and the need for adaptability in regulatory reporting. This feedback aligns with the principles set out in Article 17 of MiFID II, which mandates clear and timely communication of significant trading activities to the relevant authorities, yet also allows for a degree of discretion in how this information is solicited and reported.

The concept of "without undue delay" in reporting, which ESMA sought to clarify, was another focal point of the consultation. Stakeholders concurred on the necessity of timely notifications but requested clearer guidelines on what scenarios constitute undue delays and the potential consequences of non-compliance. This request underscores the broader challenges faced by regulators and market participants in operationalizing vague legal terms into concrete, actionable standards.

In response to these discussions, ESMA proposed the development of a notification template under the existing mandate of Article 17(7)(a) of MiFID II, which would facilitate both initial and subsequent notifications regarding algorithmic trading activities. This development would involve a Level 2 change, reflecting a regulatory adaptation that respects the need for clarity and uniformity while acknowledging the diverse operational realities across member states.

By advocating for the use of this template on a voluntary basis initially, ESMA demonstrates a pragmatic approach to regulatory change, providing firms with the opportunity to adjust to new requirements gradually. This strategy underscores ESMA's commitment to enhancing regulatory efficiency through structured yet flexible approaches, aiming to ensure that the regulatory framework not only supports the stability and integrity of financial markets but also accommodates the varied complexities of market participants.

#### 2. Testing and monitoring compliance

Building upon the foundational discussions of regulatory frameworks from the previous section, the narrative now naturally transitions into examining the practical implications of these frameworks within the domain of testing and monitoring compliance, particularly under the specifics of Regulatory Technical Standard 6 (RTS 6). This part of the dialogue centres around ensuring that the algorithms functioning in the financial markets are tested robustly enough to prevent disruptions, as detailed by ESMA.

The specific articles of RTS 6 like Article 10 on stress testing, Article 6 on conformance testing, and Articles 5 and 7 on general methodology establish a structured framework within which investment firms must operate. These articles mandate that firms maintain a distinct separation between their testing and production environments, safeguarding the market from unintended algorithm behaviours during live trading. This separation is crucial in ensuring that algorithms do not exacerbate or contribute to disorderly market conditions, especially under stress.

In light of the feedback from stakeholders regarding the current testing protocols, ESMA considered the need for more detailed guidance on behavioural testing of algorithms. The complexity of financial markets and the algorithms that operate within them necessitates a nuanced approach to testing—one that not only assesses functionality under normal conditions but also examines algorithmic behaviour under stressed market scenarios. The proposal to define disorderly trading conditions more explicitly aims to harmonize understanding across entities, ensuring that all market participants operate under a common definition that captures the essence of fair and orderly market conditions without ambiguity.

Feedback on the testing environments revealed varied experiences among stakeholders. While some firms reported satisfactory interactions with the testing setups provided, others pointed out deficiencies, particularly in the capacity of these environments to simulate complex market conditions and handle sophisticated algorithms. The need for enhancements was underscored by suggestions to improve the realism of these testing environments, reflecting the complex interplay between algorithmic strategies and actual market dynamics.

The consultations revealed a clear preference for retaining flexibility in how testing is conducted, to allow customization based on the unique needs and risk profiles of different trading firms. However, there was also a significant call for increased standardization in some aspects of the testing process to ensure consistency across the industry. ESMA's response to this feedback was to propose additional guidance that would help clarify the expected conditions and scenarios for behavioural testing. This guidance aims to strike a balance, maintaining flexibility while ensuring that critical testing outcomes, such as the algorithm's non-contribution to excess market volatility, are uniformly achieved across the board.

ESMA's consideration to refine and potentially expand the directives under RTS 6 reflects a proactive regulatory stance, aiming to adapt and evolve with the technological and market developments. This ongoing dialogue between ESMA and market participants is crucial in refining the regulatory approaches to algorithmic trading, ensuring that they remain both effective in safeguarding market integrity and flexible enough to accommodate the rapid pace of innovation in financial technology.

Transitioning from the initial focus on the stringent requirements for testing environments, the discussion now delves into the realm of annual self-assessments as mandated by Article 9 of Regulatory Technical Standard 6 (RTS 6). This regulation necessitates that investment firms rigorously evaluate their compliance with Article 17 of MiFID II, addressing several critical aspects: the operational integrity of algorithmic trading systems and strategies, governance frameworks, business continuity plans, and overall compliance considering the firm's business scale and complexity.

The European Securities and Markets Authority recognized inconsistencies in the self-assessment processes across firms, prompted by the free-format approach currently allowed. This variability has made it challenging for National Competent Authorities (NCAs) to effectively compare outcomes across firms. In response, ESMA proposed the standardization of these assessments through a harmonized format at the EU level to foster consistency and comparability, aligning this initiative with similar adjustments proposed for RTS 7 to ensure a cohesive regulatory approach across both standards.

However, the feedback from stakeholders on ESMA's proposals for a standardized self-assessment format was mixed. While some respondents saw the value in standardizing formats to ensure uniformity and legal certainty, others argued against it, suggesting that the existing processes were adequate and that a one-size-fits-all approach could be overly restrictive. They highlighted the importance of maintaining flexibility to account for the diverse nature and complexity of business models across firms. Critics of the proposal emphasized that high-level principles and the current detailed criteria in the Annex of RTS 6 were sufficient for guiding the self-assessments.

Addressing the frequency of these assessments, ESMA's suggestion to extend the interval from annual to biennial was met with general approval, contingent on NCAs having the discretion to request more frequent assessments in justified cases. This flexibility was deemed necessary to respond promptly to rapid developments in trading technologies and strategies that might impact market conditions.

Furthermore, ESMA considered incorporating more detailed information about the testing environments used by firms into the self-assessments. This move was intended to provide NCAs with a clearer picture of the testing landscape and ensure that firms were complying with the stringent testing requirements laid out in RTS 6. This proposal aligns with the overarching goal of ensuring that all algorithmic trading activities are rigorously tested and that any potential disruptions to market order can be pre-emptively identified and mitigated.

## 3. Challenges and Future Directions in Algorithmic Trading Regulation

Navigating the dynamic landscape of algorithmic trading, High-Frequency Trading, and Direct Electronic Access (DEA), ESMA continues to grapple with the implications of rapid technological advancements on financial markets. The dialogue on these topics is shaped by the evolution of market structures due to these technologies, a key focus under MiFID II directives and further elaborated in Commission Delegated Regulation (EU) 2017/589. This regulation establishes organizational requirements for firms engaged in algorithmic trading, ensuring robust governance and risk management practices.

Over the last decade, the proliferation of algorithmic trading has significantly impacted the functioning and structure of financial markets, expanding from equities and interest rates to commodities. MiFID II, with its comprehensive approach outlined in Recital (62), highlights the dual nature of trading technology—its capacity to enhance market efficiency and its potential to exacerbate systemic risks like market abuse and volatility. The broad consensus among stakeholders, as revealed through ESMA's consultations, largely supports the effectiveness of the current MiFID II framework in managing these challenges. Yet, they caution against major regulatory changes without thorough cost-benefit analyses, suggesting only targeted adjustments to refine the regime, particularly concerning the sophistication of algorithms and their broader market impact.

This feedback underscores a persistent concern: the increasing divide between entities capable of sustaining the heavy technological investments required by modern trading environments and smaller market participants. This divergence potentially concentrates risk among a few large players, posing systemic concerns that merit regulatory attention beyond existing MiFID II provisions.

As algorithmic trading evolves, ESMA's ongoing assessments and stakeholder feedback point to a nuanced regulatory landscape. The responses indicate a general satisfaction with the framework's performance, particularly during volatile periods like the COVID-19 market upheaval, suggesting that the regulatory environment has been resilient. However, there are calls for clearer guidance and possibly recalibrating the regulatory approach based on the complexity and impact of specific algorithms, reflecting a need for a more differentiated regulatory strategy that can adapt to the rapid technological advancements in trading.

The state of algorithmic trading and DEA also reveals varied practices across member states, highlighted by the disparity in notification and authorization rates across the EU. This inconsistency may affect the level playing field within the EU's financial markets, particularly post-Brexit, stressing the need for a harmonized regulatory approach.

In examining the role of circuit breakers in mitigating market volatility, feedback from various stakeholders underscores the effectiveness of these mechanisms under the regulatory framework of MiFID II, particularly Articles 48 and 19 of RTS 7. Circuit breakers have been critical during periods of extreme volatility, such as the 2008 financial crisis and the COVID-19 pandemic, ensuring market stability and preventing disorderly trading conditions.

Stakeholders have generally expressed satisfaction with the current operation of circuit breakers, emphasizing their role in maintaining order during market upheavals. However, some improvements were suggested, such as increasing transparency in how trading venues implement and manage these

mechanisms. This transparency would enable market participants to better prepare for and react during periods of imposed trading halts. Furthermore, there was a call for more consistent regulatory oversight concerning the modification of circuit breaker parameters, with suggestions for mandatory disclosures to enhance predictability for market participants.

While there is no consensus on the need for standardized synchronization of trading resumption across venues after a halt, enhancing the dissemination of information about halts could improve coordination and reduce market fragmentation. However, the diversity in market structures and the specificity of local conditions mean that a one-size-fits-all approach may not be optimal.

From a regulatory perspective, maintaining the integrity and efficacy of circuit breakers is crucial. ESMA has acknowledged the need for potential enhancements based on stakeholder feedback, suggesting that while the fundamental framework provided by MiFID II is sound, targeted improvements could refine the system further. These improvements might include clearer guidelines on the recalibration of circuit breakers and enhanced requirements for reporting and transparency to support the needs of a dynamic trading environment.

Thus, the evaluation of circuit breakers not only reaffirms their importance in contemporary financial markets but also highlights areas for refinement to better serve the diverse ecosystem of European trading venues

The past year's scrutiny by ESMA has revealed that despite the general resilience of primary markets, significant vulnerabilities persist, particularly in how outages can disrupt the broader trading ecosystem. These disruptions not only affect the primary market but also lead to proportional decreases in trading activity across alternative venues. This outcome is influenced by several factors: uncertainty regarding the status of orders during an outage and the absence of a reliable reference price, which prevents traders from migrating their activities to other platforms. This is compounded by inadequate communication from affected venues, causing further hesitancy among traders due to unclear resumption timelines.

A notable concern is the dependency of smaller trading venues on the infrastructure provided by major exchanges, which means that a single outage can ripple across multiple markets, a scenario observed with disruptions at Euronext and Deutsche Börse. This interdependence suggests that the impact of any single market's failure can extend well beyond its immediate sphere, necessitating a more robust, coordinated response mechanism across the EU.

The feedback from market participants supports the need for enhanced communication protocols during outages. ESMA emphasizes that venues must not only swiftly inform participants about disruptions but also provide regular and detailed updates regarding the status of the outage and the expected resumption of trading. This communication should be clear and use accessible platforms to ensure all market participants receive timely updates.

Moreover, ESMA notes the importance of having effective business continuity plans that aim to resume trading quickly, ideally within a two-hour window, although this target has been under review for its practicality in all situations. The review might lead to adjustments in regulatory requirements detailed in Article 15(2) of RTS 7, concerning operational resilience.

Circuit breakers have been pivotal in managing volatility, as demonstrated during the COVID-19 pandemic's market upheaval. Their effective deployment during this period aligns with the stipulations of Article 48(5) of MiFID II, underscoring their value in maintaining orderly market conditions. ESMA's guidelines on the calibration of circuit breakers and the publication of trading halts further reinforce these mechanisms' roles in stabilizing markets during turbulent times.

Looking forward, ESMA proposes not only legislative changes but also industry-led initiatives to better manage technological risks and ensure continuity in trading. This includes establishing more transparent communication strategies and possibly reevaluating the recovery time objectives for trading resumptions to align with realistic operational capabilities. Additionally, ensuring the integrity of closing auctions is critical, especially when primary markets cannot resume in time for these auctions.

While ESMA has contemplated allowing alternative venues to conduct closing auctions, the practical and regulatory complexities of such a measure require further deliberation.

The agency also acknowledges the potential role of a European consolidated tape in providing a dependable reference price during market disruptions, which could mitigate some of the challenges currently faced during outages. While legislative steps regarding this are tentative, they indicate a direction towards greater market integration and transparency.

## V. AUDERE CASE STUDY: THE IMPACT OF ACTIVE MANAGED CERTIFICATES IN THE FINANCIAL SECTOR

#### 1. Algorithmic Synergy: The Audere Team and Approach

Audere Invest SA specializes in leveraging sophisticated algorithms to guide investment strategies, distinguishing itself within the financial advisory sector. Located in Lugano, the firm caters to private, institutional, and corporate clients, assisting in investment decisions and corporate structuring. The team employs advanced quantitative models that utilize macro-economic variables to predict the price performance of various financial instruments, such as shares, precious metals, and currencies.

This focus on algorithmic solutions places Audere at the forefront of the transition from traditional economic approaches to more data-driven methodologies in asset management. The firm provides a comprehensive range of services, from asset management, where it advises banks and asset managers and manage actively managed certificates (AMCs), to family business consulting and the structuring of investment clubs. This integration of algorithmic strategies across different service areas underlines their commitment to innovation and efficiency, using state-of-the-art technology to offer market-neutral strategies that aim to yield consistent returns regardless of market trends.

Audere Invest SA's quantitative team features three pivotal members, each bringing a distinct blend of expertise crucial to the firm's focus on algorithm-driven financial strategies. The Head of Quantitative Team, having earned a dual Ph.D. in Quantitative Finance and Signal Processing Communications from Imperial College London, has developed a groundbreaking quantitative model for forecasting the prices of various financial instruments linked to commodities, forex, and large-cap equities. Under the mentorship of a prominent professor at Imperial College, he has played a significant role in shaping the research agenda in quantitative finance. His role involves generating trading signals and contributing to the firm's dynamic investment strategies.

The Head of Statistical Team, equipped with a Master's degree in Economics & Finance from the University of Venice and a background in Economics and Commerce, has garnered extensive experience in both advisory and management capacities within the Italian savings management industry, serving at notable institutions and managing significant investment funds. His responsibilities encompass the development of trading signals and sophisticated risk management models, enhancing the firm's analytical capabilities.

The Platform Architect and Senior Researcher, a Ph.D. holder in Quantitative Finance from Imperial College London, engages extensively in financial consulting in Switzerland, offering strategic advice on investment decisions, fundraising, business valuation, and liaising with financial institutions. His extensive background includes impactful positions in London's financial district, where he provided advisory services to major investment firms and contributed significantly to investment fund management. His academic and professional contributions greatly enrich the firm's research and development focus.

Together, these members form a robust foundation for Audere's quantitative analysis team, driving the adoption of sophisticated financial models that leverage big data to predict market movements, thereby transitioning from traditional economic methods to a more quantitatively-driven approach in asset management. This strategic shift underscores the increasing reliance on statistical and mathematical prowess within the financial sector, positioning Audere at the cutting edge of investment strategy design.

This transformative integration of macroeconomics, finance, applied mathematics, and other disciplines within Audere Invest SA's operations underscores the dynamically evolving nature of the financial sector. Traditionally dominated by experts primarily trained in economic theory and financial management, the field is now increasingly reliant on mathematical and statistical experts equipped to address complex and multifaceted market challenges. This significant paradigm shift in the industry has facilitated the convergence of diverse professional profiles, such as engineers, data scientists, and econometricians, who previously operated in distinct spheres within the financial landscape. By merging these varied areas of expertise, Audere Invest SA not only enhances its strategic capabilities but also sets a new standard for how interdisciplinary collaboration can drive innovation and pave the way for pioneering developments in financial strategies. This new era in finance, therefore, emphasizes the critical importance of integrating diverse knowledge bases, heralding a future where holistic and multifaceted approaches are essential for achieving success and maintaining competitive advantage in the industry.

#### 2. Exploration of the Model: gAintrader

Building upon the detailed profiles of key team members presented earlier, this section transitions to an in-depth examination of the specialized capabilities that define and enhance the operational features of the gAIntrader model. With a foundation deeply embedded in a diverse array of advanced skills, the quantitative team at Audere Invest has meticulously crafted a proprietary machine learning model. This model seamlessly integrates sophisticated computational techniques with profound financial expertise. This harmonious integration not only exemplifies the practical application of theoretical knowledge to complex problems within financial markets but also prepares the ground for a comprehensive exploration of the technical nuances inherent in the model's design and functionality.

#### a. Enhancing Predictive Accuracy with Advanced Machine Learning Techniques in Financial Modelling

The expertise in machine learning (ML) forms the core of the proprietary model known as gAIntrader, applying artificial intelligence (AI) principles to the field of numerical analysis, data processing, and forecasting of complex variables influenced by numerous underlying factors, each characterized by high levels of uncertainty. The distinctiveness of the ML model lies in its ability to harness the power of cluster analysis through two specialized techniques: dimensionality reduction and cluster identification (clustering). These techniques refine the model's predictive accuracy and its ability to manage and interpret vast datasets, which are crucial for effective decision-making in financial markets.

Dimensionality reduction addresses the "curse of dimensionality," a common challenge in financial modelling where the increase in data dimensions can lead to higher computational complexity and lower model performance. By reducing the number of variables considered in the model without significant loss of information, this technique enhances the efficiency and speed of the algorithm, which is critical in financial markets where real-time data processing and quick decision-making are essential.

Cluster identification organizes data into distinct groups based on similarities among the data points, valuable in identifying patterns and trends not immediately apparent. This method allows the model to categorize market conditions or financial instruments into groups that exhibit similar behaviors, thereby facilitating more targeted and effective investment strategies.

By leveraging these two competencies, the ML model at Audere Invest handles a greater number of determining variables/factors with high precision and efficacy in data treatment and predictive capacity. This capability ensures that the gAIntrader model can outperform existing techniques in critical areas such as prediction accuracy and the ability to adapt to new and evolving market conditions. This sophisticated approach not only distinguishes the model from traditional financial models but also enables it to tackle complex, nonlinear data in a way that traditional models cannot.

To further understand the integration of AI in the gAIntrader model, it's essential to delineate the layers of artificial intelligence and their specific roles. At the broadest level, AI encompasses the development of smart systems and machines that perform tasks which typically require human intelligence, including problem-solving, recognizing patterns, and understanding language. AI sets the foundation for more specialized techniques such as machine learning and deep learning, integral to the Audere Invest model.

Machine learning, a subset of AI, creates algorithms that can learn from data and make decisions based on observed patterns. These algorithms, vital for analyzing financial data and making predictive models, guide investment strategies at Audere Invest and require occasional human intervention to correct or improve decision-making processes when predictions are incorrect, reflecting a collaborative synergy between human experts and the automated system.

Deep learning, within the hierarchy of AI techniques, uses artificial neural networks to process data, capable of making accurate conclusions without human intervention. Driven by their ability to learn from vast amounts of data and identify complex patterns not immediately obvious to humans, deep learning is particularly beneficial for handling the vast array of variables and their interrelations within financial markets, allowing for more nuanced and precise predictions. This layered approach of AI ensures a robust and dynamic system capable of adapting to the complexities of modern financial markets, ultimately enhancing Audere Invest's predictive capabilities and operational efficiency.

Building on the foundational competencies in machine learning, Audere Invest's proprietary approach addresses several crucial challenges associated with the reduction of dimensionality in financial modelling. This step in the model's development is vital for enhancing its operational efficacy and precision in handling vast and complex datasets. One of the pivotal issues tackled by Audere Invest through its machine learning approach is the curse of dimensionality. As the number of input features increases, data becomes increasingly sparse in high-dimensional space. This phenomenon can lead to various problems including escalated computational complexity, decreased efficiency of algorithms, and a higher risk of overfitting. By effectively managing the dimensionality, the model maintains robustness and agility in predictive performance. High-dimensional data handling demands substantial computational resources as the number of calculations and memory requirements grow exponentially with each additional dimension. Audere Invest's dimensionality reduction techniques significantly alleviate this burden by compressing the input space without losing critical information, thus enhancing computational efficiency and enabling the model to operate faster and more reliably. High-dimensional datasets are particularly susceptible to overfitting where models might learn to memorize noise or irrelevant patterns rather than capturing the underlying real relationships. Dimensionality reduction plays a critical role here, focusing on the most informative dimensions and discarding extraneous noise. This refinement helps in honing the model's ability to generalize from training data to unseen data, thereby improving its predictive accuracy. Visualizing high-density data is inherently challenging as human cognition is not equipped to intuitively understand data beyond three dimensions. Audere Invest utilizes dimensionality reduction techniques to transform data into a more manageable space, facilitating clearer visualization and interpretation of complex models and relationships. This not only

aids in internal analyses but also enhances the ability to communicate findings and strategies clearly to clients and stakeholders. The primary goal of dimensionality reduction within the gAIntrader model is to retain as much relevant information as possible while eliminating noise and redundant features. Choosing the right technique and fine-tuning its parameters is crucial for striking the right balance between reducing dimensions and preserving essential information. This careful calibration ensures that the model remains precise and effective, capable of making informed predictions and decisions based on a streamlined yet comprehensive data set. Through these detailed efforts in reducing dimensionality, Audere Invest strengthens the capability of its gAIntrader model to perform with heightened accuracy and efficiency, addressing fundamental challenges that typically impede the performance of less sophisticated models in the volatile realm of financial markets.

#### b. Streamlining Cluster Analysis in Audere's ML Model

Advancing from dimensionality reduction, Audere addresses the critical task of cluster identification through its proprietary machine learning techniques. Identifying the right clustering algorithm is pivotal as each algorithm, whether it be k-means, hierarchical, or density-based clustering, comes with inherent assumptions and strengths suited to different kinds of data challenges. The selection process is intricate, demanding a keen understanding of the dataset to ensure the algorithm aligns well with the specific requirements of the model.

Determining the optimal number of clusters, often referred to as the "k" in k-means clustering, is equally challenging. This decision is crucial as an incorrect number can lead to either over or undersegmentation, significantly diminishing the model's predictive accuracy. Moreover, handling highdimensional data in clustering introduces additional complexities. Traditional distance metrics can become less effective as the curse of dimensionality impacts the accuracy of clustering outcomes.

Noise and outliers in the data can substantially degrade the quality of clustering results. Effective management of these elements is essential to maintain the integrity of the clustering process. Identifying and handling these noisy points ensures that clusters represent true patterns and not anomalies, which could skew the analysis.

The interpretation and evaluation of clustering results are inherently subjective and require careful consideration to ensure that the clusters are meaningful and actionable. Audere Invest's approach aggregates observed combinations based on homogeneity and the stability of the target variable's behaviour, forming a market universe of "stable" combinations. Each cluster is then characterized by key features such as the sign (positive or negative) related to the growth or decline of the target variable and the confidence level (high or low), providing a nuanced understanding of the predictive environment. This structured identification and evaluation framework allow Audere to harness the full potential of clustering in its predictive models, offering a sophisticated tool for navigating the complexities of financial markets.

#### c. Audere's Model Revolution

The Audere Invest model exemplifies a pioneering advancement in asset management by deploying a proprietary artificial intelligence model that is both conceptually and mathematically innovative. This innovative approach has only limited applications within the broader asset management sector, highlighting its unique position in the industry. Unlike traditional models, Audere's framework is entirely driven by sophisticated algorithms, which guarantees a non-discretionary process in forming investment strategies. This marks a substantial departure from traditional models that often rely heavily on human discretion and subjective decision-making methodologies, which are increasingly viewed as less efficient in the fast-evolving financial markets.

Audere's algorithmic model skilfully integrates an extensive array of 12-15 explanatory factors for predicting variable outcomes. This capability significantly surpasses traditional methods, such as the Capital Asset Pricing Model (CAPM) from the 1960s and 70s, which are typically confined by linear assumptions and are only able to incorporate a limited number of factors due to the challenges posed by high-dimensional data environments. Audere's methodological richness allows for an expansive analysis encompassing a broader and more complex range of data inputs, offering deeper insights and more accurate forecasts. The traditional models are rigid, often rendering them unable to adapt to or capture the multifaceted dynamics of modern financial markets.

A core innovation of the Audere model lies in its nuanced consideration of the non-linearity in correlations between explanatory variables and the target variable, acknowledging the dynamic nature of financial markets where relationships between variables are not static but vary over time. This is in stark contrast to the static correlations posited by traditional models, which fail to account for the evolving economic landscapes and the resultant market volatilities.

Moreover, the empirical distribution of returns on variables utilized in Audere's model frequently displays non-normal (non-Gaussian) characteristics, such as asymmetry and heavy tails, features that more closely mirror actual market behaviours than the simplistic normal distribution assumptions that underpin many conventional financial models. By relying on empirical data rather than theoretical models, Audere enhances the real-world applicability and accuracy of its financial analyses, ensuring that its strategies are finely tuned to actual market dynamics and complexities. This realistic modelling of financial markets stands in direct opposition to traditional models that often presume Gaussian distributions, overlooking significant risks and opportunities that arise from market anomalies.

Furthermore, Audere's sophisticated risk management tools are not merely adjunct components but are integrally woven into the model's optimization strategies. This integration encompasses advanced mechanisms like stop losses, take profits, and the minimization of drawdowns and correlations with external variables. Such an integrated approach to risk management ensures a comprehensive strategy for managing the array of risks inherent in asset management, contrasting sharply with traditional models where risk management tools are typically appended post hoc following the asset selection process.

In contrast to the slow pace of innovation in traditional asset management models that continue to rely on outdated general equilibrium models like CAPM, Audere Invest's application of AI and advanced algorithms represents a quantum leap forward. Traditional models, often constrained by their dependency on linear correlations and a limited set of explanatory factors, are rapidly becoming obsolete in the face of such advancements.

#### d. Strategic Multi-Frequency Trading Approach

Audere Invest has meticulously developed a trading model that leverages three distinct trading frequencies: daily, hourly, and weekly/monthly, each chosen for its particular strengths in harnessing the full capabilities of the model in a complementary manner. This strategic application of varied trading frequencies allows for a nuanced exploitation of data, wherein lower frequencies predominantly utilize fundamental and macroeconomic variables, while higher frequencies are optimized for technical factors such as price movements and their transformations.

The rationale behind this approach is rooted in the understanding that fundamental changes, such as shifts in inflation rates, GDP growth, or anticipated earnings, are unlikely to affect the price of a traded security within extremely short intervals, like 5-30 minutes. Instead, these macroeconomic shifts tend to influence market prices over longer periods, making them more relevant for daily to monthly trading strategies. Conversely, technical indicators, which can reflect immediate market sentiments and micro-movements, are more applicable and effective at hourly frequencies.

Over the past three years, collaborative efforts between Audere Invest and IASSEM have been focused on pinpointing key market factors that could potentially impact asset prices significantly. This rigorous analysis has primarily enhanced the firm's daily and hourly trading strategies. Audere's research team has effectively identified 10 to 15 fundamental and macroeconomic factors for a selected range of tradable assets, including major indices and commodities like the S&P500, Nasdaq100, Stoxx50, Gold, and Crude Oil. Through a sophisticated optimization process grounded in their proprietary machine learning methodology, these factors have proven to be highly predictive of price movements.

The dual advantages of identifying high-quality factors and reducing complexity through managing a large number of variables have been instrumental in achieving compelling results. These outcomes are evidenced not only in terms of absolute returns but also in the stability and reliability of performance over time.

#### e. Customizable Risk Management and Trading Filters

Audere Invest introduces a sophisticated risk profile customization in its trading platform, enabling users to fine-tune their investment strategies based on specific risk-return parameters. Once clusters are defined as non-linear combinations of explanatory factors, the model is capable of generating predictions and trading signals through user-selectable filters that tailor investment approaches to individual risk tolerances and financial objectives.

The first filter option, MAX RETURN, allows the model to operate unfettered, striving to maximize returns within a selected time frame without any risk constraints. This setting is ideal for aggressive investors seeking the highest possible returns, irrespective of potential volatility.

For those more risk-averse, the MIN DRAWDOWN filter provides a crucial function. Users can set thresholds to exclude trading signals that, although potentially high-return, carry drawdowns that exceed their comfort levels. This filter helps in preserving capital by minimizing potential losses during downturns.

The MAX SHARPE RATIO represents a balanced approach, optimizing the trade-off between maximum return and minimized drawdown. This filter adjusts the investment strategy to achieve the best possible risk-adjusted returns, making it a prudent choice for investors who seek both stability and profitability.

An illustrative example can be seen where the model excludes a particular cluster, marked in red, from forecasts because its risk-return characteristics do not align with the user-imposed risk and drawdown limits. However, this cluster, despite being excluded, shows attributes of stability and density conducive to maximizing returns under different settings.

This flexible approach to risk management allows Audere Invest to accommodate a wide range of investment styles and risk appetites, making it a versatile tool for both conservative and aggressive investors.



#### f. A Versatile Platform for Multi-Asset Trading

The gAIntrader platform developed by Audere Invest offers a robust suite of features designed to accommodate a variety of trading styles and preferences. Key functionalities include the signal generation and trade execution options available for each trading timeframe. Users can opt for the signal-only function, which positions gAIntrader as a consultative tool rather than a direct trading instrument. Alternatively, they can engage the trade execution function, which necessitates entering trading account details; this feature is specifically configured for operation with Interactive Broker platforms.

In terms of data sourcing, gAIntrader allows users to define the origin of the pricing data that fuels the model. Options include downloading prices via a browser from selected financial data sites tailored to the type of variables involved, or directly from Interactive Broker using a gateway, which requires real-time data access and a secondary account password.

A distinctive aspect of gAIntrader is its capability to handle multiple assets. Users can trade a wide array of assets that have already undergone the clustering process for optimization, including major stock indices like Stoxx50, Nasdaq100, and S&P500, commodities such as gold and oil, and individual company stocks like Apple and Tesla. The addition of new assets or indices is a feature of the premium service offered by Audere Invest, and these assets can even be synthetic, defined by the user themselves.

Moreover, the platform is designed to manage numerous accounts simultaneously at Interactive Broker, allowing each to be a managed account, certificate, or fund. This functionality is crafted to be user-friendly and flexible, enabling managers to oversee all open positions across various managed accounts effectively. The platform's capacity to provide various levels of customization regarding asset coverage and the number of managed accounts is a testament to its advanced technological foundation.

Before utilizing gAIntrader, users have the opportunity to simulate their desired strategy through a back testing platform engineered to optimize the strategy's performance against specific risk-return objectives. This includes primary optimization, conducted by Audere Invest's research team, which focuses on clustering and signal generation for maximum return objectives, and secondary optimization, controlled by the user, tailored to their individual risk-return preferences. This layered

approach to optimization ensures that each user can mold the platform's capabilities to best fit their strategic goals, reflecting the platform's versatility and advanced technological integration.

#### 3. Innovating Financial Architecture and the Foundational Services

#### a. Architecture

Here, we delve into the advanced system architecture of Audere Invest SA, highlighting its essential role in the firm's operational and strategic initiatives. This architecture transcends the traditional role of a structural framework; it is a dynamic conduit for the relentless flow of data, adeptly transforming complex information into actionable insights. These insights are crucial for maintaining Audere's competitive edge in the fast-paced and constantly evolving fintech sector. The architecture at Audere Invest SA is exquisitely designed around a central algorithm which processes a comprehensive assortment of big data sourced from numerous providers. Each provider is carefully selected based on market dynamics and asset types, making the algorithm a critical central processing hub that sifts through and synthesizes vast volumes of data to produce refined, actionable outputs essential for the company's strategic operations. A sophisticated database interfaces seamlessly with this central algorithm, functioning as both a repository and a processing node. This database is pivotal, storing processed information and preparing it for various operational needs, including facilitating consultations. It serves as an indispensable bridge between raw data inputs and the polished analytical products that emerge, embodying the missing direct output arrow in architectural visuals which symbolizes the ongoing development and refinement in the utilization and processing of data.

The bridge, an application that communicates through APIs with both the database and various trading platforms, is the most crucial output of this architecture. This bridge plays a vital role in translating algorithmically processed data directly into market actions, enabling real-time trading decisions. This setup underscores the interconnected nature of modern trading systems where immediacy and accuracy are of the utmost importance, directly impacting market execution by converting data into actionable market strategies.

The circular flow of data, vividly depicted in the system's architecture, emphasizes an innovative approach to market engagement. The architecture is designed in a way that big data is not merely processed to extract insights but is continuously recycled back into the system, creating a self-enhancing loop of data refinement. This cyclical process optimizes the firm's ability to pinpoint and exploit market inefficiencies, progressively enhancing market efficiency and mitigating traditional constraints of time and reaction speed.

This architectural framework reflects Audere's strategic commitment to spearheading fintech innovation by seamlessly integrating data processing with direct market interaction, thereby establishing a new industry benchmark for dynamically managed and executed investment strategies. The firm's approach offers a stark contrast to traditional asset management strategies, which typically rely on slower, more segmented processes.

The continuous and automated nature of this system reinforces Audere's overarching institutional strategy to not only engage in the market but to actively influence its dynamics. By utilizing quantitative data and advanced algorithms, Audere bypasses traditional emotional or trend-based trading, focusing instead on a systematic, empirical approach designed to perform robustly across various market conditions and asset frequencies.

#### b. Foundational Services

The foundational services provided by Audere Invest SA, as shown in the diagram, demonstrate the firm's holistic approach to asset management, highlighting a synthesis of technological adoption and autonomous financial products. This blend includes Signals, Actively Managed Certificates, and a comprehensive framework for Auto-Managed Accounts, all set within a technology-driven operational context.

The Signals service offers clients essential trading signals, which are the actionable outputs generated by Audere's advanced algorithmic models. These signals, suggesting buy or sell decisions, originate from the firm's proprietary trading system that processes and analyses vast quantities of market data in real time. This system exemplifies the practical application of the previously discussed advanced data architecture, enabling the firm to capitalize on real-time market opportunities through precise and empirically grounded trading recommendations. Adjacent to this, the AMC represents a more structured investment product. Actively Managed Certificates offer enhanced flexibility and personalization in investment strategies, merging algorithmic insights with structured financial product offerings. This allows investors to benefit from strategies tailored to their risk profiles and investment objectives, managed within the context of Audere's technological capabilities.

The Auto-Managed Accounts service highlights Audere's commitment to harnessing technology to transform the management of client portfolios. Unlike traditional accounts which often require significant manual oversight, these accounts are designed to operate autonomously, utilizing algorithms to manage assets based on pre-set criteria and real-time data analysis. This shift not only reduces the necessity for manual intervention but also ensures that investment decisions are made swiftly and based on systematic, data-driven insights. The implementation of such technology in asset management signifies a shift away from traditional methods, focusing instead on automation and precision to enhance investment outcomes and operational efficiency.

The Technological Adoption reflects strategic emphasis on leveraging cutting-edge technologies to redefine asset management practices. This adoption transforms how financial services are delivered and consumed, marking a departure from traditional asset management practices to a more integrated, technology-first approach that utilizes big data analytics, algorithmic trading, and automated systems management to boost efficiency and performance.

By providing a range of services that include both the generation of trading signals and the management of complex investment vehicles through technology, Audere positions itself at the forefront of the financial sector's evolution. This approach not only serves the savvy investor looking for dynamic, market-responsive investment solutions but also aligns with the broader industry trend towards automation and enhanced data utilization in financial decision-making.

This integration between services and architecture points toward a future where financial markets operate with heightened efficiency and where investment management becomes increasingly aligned with technological innovation, providing empirical proof of concept that propels the industry forward.

#### 4. Proving the Transformation with Audere's Algorithm

The growing reliance on algorithmic processes in asset management is not just an evolutionary step but a revolutionary leap in how financial markets operate. As explored in this thesis, the shift from traditional management approaches to algorithm-driven strategies marks a crucial transformation in the financial landscape. Through the lens of the Audere Invest algorithm, this work examines the broader implications of artificial intelligence and machine learning in revolutionizing asset management strategies. By integrating these advanced technologies, firms are fundamentally changing how investment decisions are made, enhancing efficiency, accuracy, and profitability. This section aims to build on the key themes of the thesis by illustrating how the Audere Invest model epitomizes this transformation, while also comparing it with traditional management practices, thus aligning the core of the thesis with the practical application of cutting-edge financial technology.

The Audere Invest algorithm is strategically designed for low-frequency trading, a method that involves executing trades over extended periods, such as daily, weekly, or monthly intervals. This approach is particularly advantageous for long-term investors who seek to reduce exposure to the volatility and noise typically associated with higher-frequency trading. By relying on low-frequency data, the algorithm can sift through a massive quantity of market information, identifying long-term trends that might be overlooked by short-term, reactionary models. This allows the Audere Invest model to focus on substantial market movements, rather than responding to fleeting price changes. In doing so, it enhances the probability of capturing enduring trends and avoiding the pitfalls of minute-to-minute fluctuations, which often cloud the judgment in traditional, high-frequency trading models.

Another significant advantage of the Audere Invest algorithm lies in its full automation. This fully automated system extends beyond the generation of trading signals to include the execution of trades, which is a crucial distinction from semi-automated or discretionary models that require human oversight at various stages. By automating the entire trading process, the Audere Invest algorithm minimizes human errors, delays, and emotional biases that can interfere with trading decisions. It ensures a seamless, uninterrupted flow of data-driven decision-making, from signal generation to trade execution, optimizing both speed and accuracy. This complete automation significantly reduces latency in decision-making, as the algorithm reacts to market data instantaneously, far outpacing any human-driven model in terms of both speed and precision. As a result, the algorithm guarantees a more consistent application of strategy, unaffected by the unpredictability of human intervention.

The versatility of the Audere Invest algorithm exemplifies the evolving landscape of asset management, where traditional active management practices are increasingly supplemented or even replaced by automated solutions. Although the algorithm is capable of functioning in an active management capacity, where it utilizes advanced data analytics to predict asset prices and attempt to outperform the market, the broader industry trend is moving towards automation and efficiency. In volatile markets, where traditional active management may falter due to human biases and slower reaction times, the algorithm's capability to rapidly process and act on complex market data highlights the growing relevance of machine learning and AI in investment strategies.

Conversely, the algorithm's role in passive management involves tracking indices or following predefined rules, focusing on replicating market performance with minimal costs and risks. This use case aligns more closely with the industry's shift towards passive management, emphasizing cost efficiency and risk minimization over the potentially higher returns of active strategies. The integration of such advanced technologies in traditional settings illustrates a significant shift, suggesting that even when active strategies are employed, they are increasingly reliant on technological enhancements to maintain competitiveness.

This nuanced functionality of the Audere Invest algorithm underscores the complex interplay between active and passive management approaches in modern asset management, demonstrating that while

the tool can support traditional active strategies, its real strength lies in enhancing efficiency and precision—qualities that are pivotal to the sustained shift towards passive management.

A cornerstone of the Audere Invest algorithm's design is its ability to identify and exploit market inefficiencies. Traditional asset management models often operate under the assumption that markets are largely efficient, leaving little room for arbitrage. However, the Audere Invest model directly challenges this belief by demonstrating that inefficiencies do exist and can be exploited for profit. By continuously processing vast amounts of data, the algorithm identifies discrepancies in asset pricing that occur due to information asymmetry or short-term market conditions. This ability to capitalize on small but significant price variations enables the algorithm to extract value from opportunities that human traders or traditional models might miss. The key here is the algorithm's capacity to respond in real-time to shifting market conditions, enabling it to quickly act on these inefficiencies before they are corrected by the market. This feature exemplifies the core thesis assertion that modern algorithmic models, such as Audere Invest's, are far more adept at navigating market complexities than traditional discretionary methods.

Unlike human traders who are limited by work hours and cognitive capacity, the Audere Invest algorithm operates 24/7, continually monitoring and analysing global markets. This around-the-clock trading capability allows the algorithm to maintain market activity at all times, ensuring that it can respond to fluctuations or opportunities no matter when they occur. By trading on a global scale and across multiple asset classes—ranging from equities to commodities—the algorithm enhances market efficiency by filling in the gaps left by human traders or traditional market models. In fact, this uninterrupted trading activity helps stabilize markets by providing liquidity and price discovery during times when market activity would typically wane, such as off-peak hours or during periods of high volatility. Over time, the continuous application of such an algorithm could lead to more balanced and efficient markets, reducing instances of extreme volatility and improving overall market functionality.

A significant strength of the Audere Invest algorithm is its ability to continuously gather data and adapt in real-time. This real-time data processing ensures that the algorithm can adjust its strategies based on the latest market developments, which is critical in today's fast-paced financial environment. Unlike traditional models that may require manual recalibration or periodic adjustments, the Audere Invest algorithm is constantly refining its approach based on incoming data. This dynamic nature of the algorithm serves as empirical evidence that advanced, data-driven models can outperform static, traditional ones, which often struggle to keep pace with rapidly changing markets. This adaptability not only enhances the accuracy of predictions but also aligns with the thesis assertion that algorithmic models represent a fundamental shift toward more efficient, real-time financial management.

The ongoing learning and adaptation of the algorithm exemplify a broader transformation in asset management. By relying on real-time data and continuously refining its strategies, the algorithm embodies a shift away from the traditional, often static approaches that have dominated asset management for decades. This transformation, from discretionary, human-driven management to dynamic, automated systems, represents a significant leap forward in the field, heralding the future of asset management where data-driven, algorithmic models will likely play a dominant role.

The versatility of the Audere Invest algorithm is evident in its application across a wide array of financial services, from fintech-driven research to advanced investment management strategies, such as AMCs (Actively Managed Certificates). Its ability to customize strategies and adapt to various market conditions makes it an invaluable tool in the evolving fintech landscape. This adaptability allows the algorithm to cater to different segments of the financial industry, whether it is used for independent research, as a core component of an actively managed investment fund, or even as an advisory tool for larger financial institutions.

The adoption of the Audere Invest algorithm and similar models across the financial sector underscores the rapid technological transformation occurring within asset management. Not only are fintech companies leading the way with these innovations, but established financial institutions are also integrating these technologies into their operations. This includes their use in treasury management, automated managed accounts, and more complex financial services. The ease of integration and the high degree of customization offered by such algorithms make them indispensable in the modern financial ecosystem, paving the way for a future where traditional management is increasingly replaced or augmented by AI and machine learning-driven processes.

The Audere Invest model represents a fundamental strategic shift from traditional asset management models. Unlike traditional strategies, where algorithms are often used as supplementary tools, Audere Invest has placed the algorithm at the very centre of its decision-making process. In traditional management, the human factor plays a critical role in interpreting data and making final decisions, which can introduce inefficiencies and delays. In contrast, the Audere Invest algorithm makes these decisions autonomously, reacting to data far faster and more accurately than any human-driven process could. This shift away from human discretion and toward a fully automated, algorithm-driven approach exemplifies the broader evolution in asset management, where advanced technology plays a pivotal role in shaping the future of the industry.

To conclude, it is important to note how major European banks such as BNP Paribas are now actively engaging in the development and deployment of algorithmic trading models. By committing to Actively Managed Certificates, BNP and other financial giants are recognizing the transformative power of algorithmic trading. These institutions are not just dipping their toes into the world of algorithmic asset management—they are committing resources and effort to become leaders in this space. This growing trend among the world's most powerful financial institutions further validates the thesis that algorithmic trading is not just a complementary tool but a fundamental component of the future of asset management.

Moreover, FinecoBank is another poignant example<sup>59</sup>, as it has been making strides in enhancing its platform to cater to sophisticated trading needs and client demands for managing more complex portfolios. Although Fineco is well-positioned due to its robust trading history and client base eager to advance into more complex asset management, it remains on the fringes of fully automated trading capabilities. Until it offers these functionalities, it may not fully capitalize on the benefits of fintech innovations. This situational overview illustrates the significant, yet gradual shift towards integrating more advanced, automated systems across the European banking landscape.

Through the analysis of the Audere Invest algorithm, it becomes clear that the broader industry is moving toward a fully automated and data-driven future.

#### a. Financial Institutions and Algorithmic Trading, the case of BNP

As we've seen, major financial institutions like BNP Paribas are not just adapting to but are at the forefront of the revolution in algorithmic trading. This transition marks a pivotal shift towards embracing and institutionalizing advanced trading models. Actively Managed Certificate by BNP Paribas exemplify this strategic shift, where traditional financial powerhouses harness the efficiencies of automation and advanced data analytics to redefine asset management. The following discussion delves into the specifics of BNP's AMC offerings, examining how these products leverage algorithmic strategies to meet the sophisticated demands of modern investors and set new benchmarks in the financial sector.

The AMC issued by BNP Paribas<sup>60</sup> (ISIN XS2828433156) is designed as an active management tool that utilizes a sophisticated algorithm developed by Algorithmica SA, serving as the technology provider and Index Advisor. The AMC, under the ticker ENHALLX1, is listed on the Borsa Italiana,

<sup>&</sup>lt;sup>59</sup> See https://pitchbook.com/profiles/company/114635-44

<sup>&</sup>lt;sup>60</sup> All data are related to Audere Invest elaborations

Fees and Investment Parameters:

- Subscription Fee: 0.0%
- Management Fee: 2.0%
- Performance Fee: 20% (High Water Mark)
- Minimum Investment Amount: €1,000
- Emission Price: €1,000
- Maximum Exposure: +/-150%
- Entry/Exit Costs: 0.50%

This AMC is designed for long-term capital growth by investing in a diverse portfolio that includes precious metals, industrial commodities, equity indices, currencies, and investment-grade government bonds. The investment strategy employs a low-frequency machine learning algorithm that dynamically manages gross exposure to hedge against downside risks and generate market-neutral returns. The algorithm's asset selection is non-discretionary, utilizing consensus enterprise variables and macroeconomic market data, and it delivers weekly forecasts on asset price movements. Exposure management is algorithmically calculated based on an inverse proportionality rule to volatility, ensuring the portfolio adapts effectively to current market conditions.

From 2022 to 2024, the focus of the investment strategy has been on managing individual costs, which has enhanced the financial efficiency of the portfolio. Performance metrics and compositions are updated weekly on the gaintrader.ch website. The adjusted historical returns factor in management fees of 2.0%, transaction costs of 0.05% per trade with a weekly portfolio turnover, and a performance fee of 20.0%. These metrics underscore a significant decorrelation from market movements with a Beta of 0.13, indicating a minimal systemic risk.

The risk management guidelines ensure that the gross exposure of the portfolio is maintained within a range from -1.5 to 1.5 times the managed assets. The asset weighting is inversely proportional to the volatility of the returns, which aids in balancing the portfolio against market fluctuations. Additionally, trading activities are confined to liquid asset classes such as listed futures, options, ETFs, major stock indices like the S&P 500, Nasdaq, and Eurostoxx 50, investment-grade bonds, and major international currencies, ensuring robust risk management and compliance with market standards.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	YTD
2022	2,19%	4,03%	10,43%	4,99%	3,87%	6,35%	9,47%	3,23%	5,95%	4,67%	7,87%	4,51%	67,5%
2023	4,99%	3,31%	8,11%	3,55%	1,95%	4,99%	4,91%	1,15%	3,07%	4,03%	5,15%	6,67%	51,8%
2024	3,39%	3,31%	3,79%	3,71%	2,99%	2,11%	1,07%	2,67%					23,0%

Historical returns adjusted for costs - monthly and YTD from 01.01.2022, in %:

The results produced over the last two and a half years with BNP's AMC have been quite compelling, demonstrating substantial decorrelation from general market trends, as evidenced by a Beta of 0.13. This indicates that the strategy performs independently of market movements. The gross return, inclusive of all costs, reached an impressive 187.73%, with the maximum weekly drawdown recorded at -0.44%. These outcomes were achieved with a contained gross exposure, totalling 122% when considering both long and short positions. Notably, the strategy's approach to weighting assets inversely proportional to their volatility has proven effective. A pie chart illustrating this method shows that each asset contributes equally to the overall strategy's returns, ensuring that no single asset disproportionately affects the portfolio's performance. This balanced contribution enhances the strategy's stability and potential for consistent returns.



#### Comparison COMETA and S&P 500

	COMETA	S&P500
Inizio periodo	21/01/2022	21/01/2022
Fine periodo	07/09/2024	07/09/2024
Rendimenti cumulati	187,73%	0,23%
Esposizione lorda media	122,69%	100,00%
Volatilità annualizzata	16,10%	17,84%
Sharp Ratio	3,05	0,86
Alpha	0,50	
Beta	0,13	
MTD Return	-0,44%	-4,41%
3M Return	6,79%	0,80%
6M Return	20,56%	5,58%
1Y Return	55,50%	20,42%
YTD	30,39%	13,94%
Best Week	5,57%	6,18%
Worst Week	-0,44%	-6,15%
Best Month	13,43%	8,35%
Worst Month	-0,44%	-10,30%
Drawdown Sept (2022)	-0,21%	1,51%
Drawdown Sept (2023)	-0,19%	2,50%
Drawdown Sept (2024)	-0,15%	1,54%

#### VI. CONCLUSION

This thesis provides a comprehensive exploration of the transformative impact of financial technology and algorithmic advancements on the landscape of financial management. It begins with a detailed introduction to the evolution of FinTech, setting the stage for an in-depth examination of its disruptive impact across various financial practices.

As the narrative unfolds, it delves into the significant changes FinTech innovations, such as blockchain, artificial intelligence, and algorithmic trading, have brought to traditional banking. These technologies are redefining cost structures, enhancing operational efficiencies, and challenging established financial norms. The integration of such technologies has proven crucial in transforming asset management, as they provide enhanced analytical tools and improve responsiveness to market dynamics.

The discussion further extends to the concept of low-frequency trading, which exemplifies the merger of traditional financial principles with modern technological advancements. This approach emphasizes the strategic use of technology to achieve consistent investment returns, contrasting with the often speculative nature of high-frequency trading.

The thesis progresses by highlighting the shift from traditional discretionary management to structured, technology-enhanced methodologies. This transition is supported by data showing a decline in the effectiveness of active management and the rising prominence of passive investment strategies, as evidenced by their robust performance during market volatilities.

Moreover, the emergence and proliferation of Exchange-Traded Funds are discussed. ETFs have highlighted the limitations of active management and have become instrumental in the evolution of investment strategies, incorporating both passive and active management elements to meet specific financial goals.

The penultimate chapter addresses the complexities of regulation in algorithmic trading, outlining current regulatory frameworks and the challenges they face. This sets the groundwork for discussing future directions and the need for balanced regulatory approaches that foster innovation while managing risks.

This thesis culminates with a case study on Audere Invest SA, effectively anchoring the theoretical discussions presented in previous chapters into a tangible examination of contemporary algorithmic trading practices. This final exploration not only validates the extensive analysis of the transformative impacts of FinTech and algorithmic advancements on financial management but also highlights the practical implementation of these technologies in a real-world setting.

The case study of Audere Invest SA showcases how algorithmic trading, specifically through the use of the gAintrader model, revolutionizes asset management. This model employs a sophisticated machine learning algorithm designed for low-frequency trading, which strategically integrates both passive and active management elements. This hybrid approach allows for the efficient handling of various asset classes through systematic and non-discretionary methodologies, demonstrating a significant shift from traditional asset management practices.

The Audere model is distinctive for its ability to process and analyze vast arrays of data to produce reliable trading signals without human intervention. This capability illustrates a critical evolution from the high-frequency trading models that focus solely on speed and short-term gains to a more comprehensive, strategic approach that values stability, long-term growth, and the mitigation of risks.

The success of this model and its methodologies provides empirical evidence supporting the thesis' assertion that the future of financial management lies in the integration of advanced algorithms. The case study details how Audere's approach aligns with regulatory standards and adapts to market conditions, thereby offering a scalable and efficient solution that traditional asset management practices cannot match.

The case study not only demonstrates the practical application of advanced algorithmic strategies but also highlights the broader adoption of such technologies by major financial institutions like BNP Paribas. This inclusion of BNP Paribas exemplifies how major European banks are increasingly engaging in algorithmic trading, thereby embracing technological advancements to remain competitive in the global financial market.

In conclusion, this thesis articulates a clear and comprehensive understanding of how FinTech and algorithmic innovations are reshaping the financial industry. It emphasizes the role of these technologies in driving the evolution of asset management practices and regulatory frameworks, ensuring market integrity and stability. By integrating theoretical insights with practical examples, this work illuminates the profound impact of technological advancements on the financial sector, marking a significant shift towards more efficient, transparent, and automated financial processes.