



Exploring opportunities and challenges of advanced research techniques of artificial intelligence in financial engineering

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Abstract

This research is based on an extensive review of existing literature with the primary objective of examining the opportunities and challenges associated with the advanced research techniques of Artificial Intelligence in the area of Financial Engineering. The literature underscores that Artificial Intelligence plays a crucial role in educating and disseminating knowledge to a diverse audience interested in finance, encompassing financial learners, aspiring professionals, young enthusiasts, and students. Furthermore, Artificial Intelligence is instrumental in fostering the development of personalized and sophisticated mainstream and alternative economic and financial tools, products, models, services, systems, and applications, not only delivering enhancements but also prioritizing safety and innovation. This study contributes to the field by providing a comprehensive examination of the opportunities and challenges associated with employing Advanced Research Techniques of Artificial Intelligence in Financial Engineering.

Keywords: Artificial intelligence, financial engineering, advanced research techniques, opportunities, challenges, financial activity, fintech.

1. Introduction

Financial engineering involves the application of mathematical methods to address financial challenges. This discipline harnesses insights and techniques from computer science, statistics, economics, and applied mathematics to tackle existing financial issues and develop novel financial products. Financial engineering is also known as quantitative analysis and is employed by traditional commercial banks, investment banks, insurance companies, and hedge funds. AI will create as many new AI-based jobs as it will displace (BBC News, 2018) which will further reinforce the adoption.

1.1 Objectives of study

- i. To gain insight into various financial engineering prospects.
- ii. To emphasize the best literature review related to the research.
- iii. To understand the role of AI in finance.
- iv. To explore contemporary research in AI within the financial domain.
- v. To provide an outlook on the benefits and future demand for AI in finance

2. Literature review

Artificial Intelligence plays a crucial role in transforming manual labour into intelligent automation, offering the potential for enhanced financial decision-making in both the present and the future. AI holds a unique and irreplaceable position in addressing various challenges in the realms of Smart Eco Fin and FinTech (Cao, 2018). The study (Bahrammirzaee, 2010) elucidates how AI-driven financial applications can influence decision-making behaviours in uncertain scenarios. Furthermore, a study (Fethi, 2009) explores the utilization of neural networks, multi-criteria decision methods, and support vector machines to assess the underperformance of banking systems. The findings indicate that while these approaches enhance profit and capacity efficiency, they fall short in predicting credit ratings for banks and employees, as (Lin, 2019) notes.

Artificial intelligence is actively involved in operational activities within the finance sector, simplifying financial transactions, improving profitability, reducing costs, enhancing accessibility, and increasing efficiency. It also scrutinizes structural risks and financial limitations through AI, addressing issues related to data integrity, bias, and risk measurement in finance. The innovation introduced by (Johnson, Pasquale & Chapman, 2019). demonstrates how AI and machine learning are revolutionizing finance, with the ultimate goal of enabling machines to make impeccable financial decisions without any fraudulent activities.

As outlined in (Kumari, Kaur & Swami, 2021), the integration of artificial intelligence in finance offers an opportunity to develop and implement advanced systems for financial technology, resulting in more efficient and optimal financial services. The study encourages the adoption of new financial modelling approaches to raise awareness about the potential of artificial intelligence in the finance sector. Future research endeavours should prioritize the practical implementation of AI in the financial industry.

3. Different types of financial engineering prospects

In foreign exchange market trading, engineers leverage the foreign exchange market to enhance corporate earnings and access global markets. The company typically manages a portfolio of various currencies from different countries, with a primary emphasis on currency exchange rates. Financial engineers can predict currency exchange rate fluctuations, enabling affiliated brokers to strategically trade currencies for profit optimization and risk mitigation. In derivatives trading financial agreements do not possess straightforward monetary worth and can be tied to interest rates, indices, or assets. Furthermore, the assessment of derivatives depends on the progressive performance of the underlying asset, offering financial engineering experts expanded prospects for potential profits.

4. AI in financial engineering

Artificial intelligence entails the emulation of human intelligence using machines. According to (Minsky, 1968), it's described as "the science of making machines perform tasks that would require human intelligence."

With the ongoing advancement of artificial intelligence (AI), there is a growing interest in integrating AI techniques into the field of financial engineering, leading to the emergence of what is now referred to as AI-driven financial engineering. New regulations have intensified the demand for AI implementation, compelling banks to adopt continuous automation and incorporate new analytical tools, which often include AI and machine learning (Adobe, 2019; Azar, 2012).

AI-driven financial engineering harnesses AI and machine learning algorithms to analyse extensive financial datasets, generate predictions, and provide valuable insights for guiding investment decisions and risk management strategies. This involves the development and deployment of AI models capable of studying historical financial data, identifying patterns, and uncovering trends that might not be readily apparent to human analysts.

Figure 1 is a prediction about the AI market from 2022-2032. In 2022, the worldwide artificial intelligence (AI) market had a valuation of approximately USD 454.12 billion, and it is projected to reach about USD 2,575.16 billion by 2032. This growth is anticipated to be driven by a compound annual growth rate (CAGR) of 19% from 2023 to 2032.

Key takeaways

- In 2022, North America contributed more than 36.84% of the market's total share.
- The Asia Pacific region is projected to experience the highest Compound Annual Growth Rate (CAGR) of 20.3% from 2023 to 2032.
- Deep learning technology, in 2022, held a market share of 36.36%.
- Services emerged as the dominant solution, capturing a market share exceeding 39.64% in 2022.
- Among end users, the BFSI sector represented 16.82% of the market share in 2022.

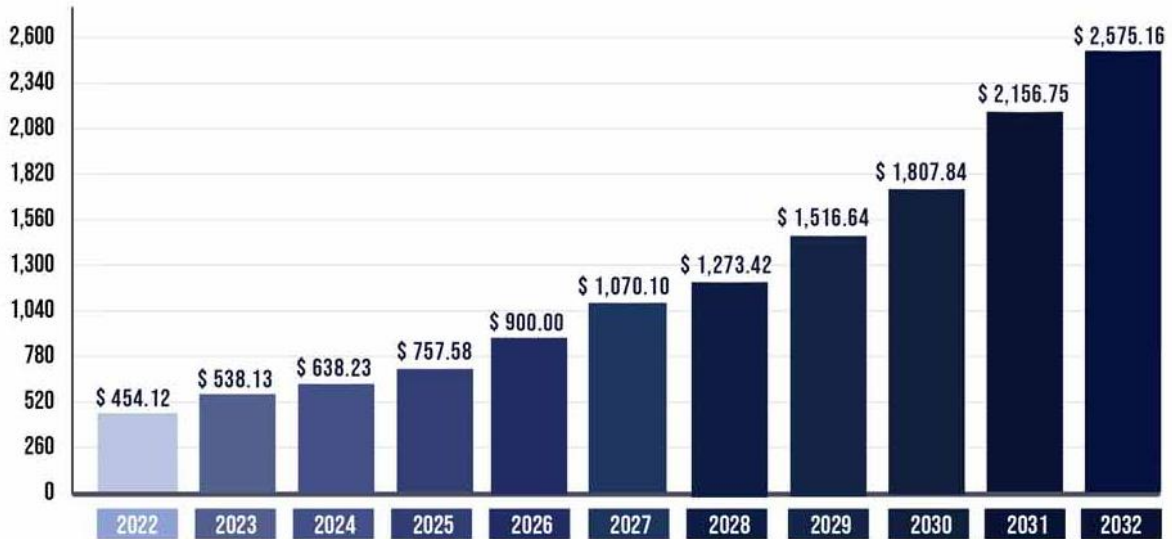


Figure 1: Predicted AI market size, 2022 to 2032(USD billion): Bahrammirzaee (2010)

5. Predictive modelling and forecasting

Predictive modelling and forecasting are considered fundamental aspects of AI-based financial engineering. When AI models are trained on historical financial data, future market trends, asset prices, and investment returns can be predicted. Various machine learning algorithms, such as regression, time series analysis, and deep learning, are employed by these models to capture the complex relationships and dynamics present in financial markets.

Through predictive modelling, insights into market movements can be gained by financial practitioners, potential opportunities can be identified, and risks can be managed more effectively. These models can be used for asset allocation, portfolio optimization, and hedging strategies. By incorporating AI techniques, financial engineering aims to enhance the accuracy and reliability of financial predictions, enabling investors to make informed decisions.

6. Risk management and portfolio optimization

Risk management constitutes a vital component of financial engineering, and AI-driven methods present valuable resources for assessing and handling financial risks. AI models can scrutinize historical data and prevailing market conditions to detect possible risks and weaknesses within portfolios. Through the utilization of machine learning algorithms, these models can replicate and gauge the influence of diverse risk factors on investment portfolios.

AI-centric risk management also encompasses the development of advanced strategies for optimizing portfolios. These strategies aim to construct investment portfolios that strike a balance between risk and return while considering multiple constraints and objectives. Machine learning algorithms can fine-tune portfolio weights, asset allocations, and risk exposures based on historical data and market dynamics.

By incorporating AI into risk management and portfolio optimization, financial engineering offers more advanced and data-informed methodologies for risk mitigation, performance improvement, and the achievement of desired investment goals.

7. Modern research on AI in finance

E-commerce encompasses traditional online activities such as business operations, shopping, and transactions. It is gradually progressing into a modern, all-encompassing system that interconnects and communicates with Internet services, mobile devices, IoT devices, Wi-Fi devices, and the users of these devices. Consequently, AI techniques can be effectively employed to tackle a multitude of established and emerging challenges and requirements within the realm of e-commerce, as indicated (Kauffman, Srivastava & Vayghan, 2012; Cao et al., 2008).

8. Research methodology

The research approach employed here is a combination of desk research and conceptual inquiry. This study is intended to benefit contemporary financial enthusiasts and students studying management who seek to acquaint themselves with financial concepts. The research design relies on personal reading, and a keen focus on the conceptual framework of artificial intelligence in financial performance. The inclusion criteria consist of recent studies to ensure the literature from 13 articles which reflects the exploration of opportunities and challenges associated with advanced AI research techniques in financial engineering. The exclusion criteria omit studies with a general focus on AI in other areas.

8.1 Data collection

This study involved the examination of data obtained from secondary sources, which encompassed materials like books, research papers, journal articles, internet reports, and newspaper articles. Relevant literature for the chapters was searched using the following search engines and databases: Springer, Research Gate, Academia, Adobe, and Google Scholars. The significance of obtaining information was underscored by ensuring that the correct citation styles were followed and credit was given to everyone who contributed.

9. Findings and discussion

The process of data acquisition revolves around technological advancements and the impact of AI within the financial sector. To impart an understanding of technology's integration in finance and to depict the role of AI in the financial domain, refer to Table 1.

Table 1: AI in finance: Stages of technology reform finance sector: FinTech (2020)

S. No	Development Stages	Reform Technology	Model/Services	Financial Performance	Impact of Technology on Finance
1.	Fintech 1.0	Computer (Information Technology in Finance)	i) Credit Card, (ii) ATM, (iii) CRM etc.	Low	Technology as a tool in Finance.
2.	Fintech 2.0	Mobile Internet (Internet in Finance)	(i) Third Party Payment (ii) E- Insurance (iii) E-banking (iv) Crowdfunding (v) E-Commerce etc.	Medium	Technology reforms financial activity such as offers and services to ease and convenience.
3.	Fintech 3.0	AI, Big data, Block Chain, Data Science (AI in Finance)	(i) Intelligent Finance (ii) Data Automation etc.	High	Technology helps to make financial decisions with Machine intelligence.

The current evaluation of Artificial Intelligence's performance in the financial sector provides a contemporary perspective. For additional insights, consult Table 2, sourced from (Sharma, Begde & Sane, 2024), as it pertains to this study. This table encompasses various financial domains, including Financial Institutions and Services, Financial Markets, E-Financing, Financial Modelling, and Financial Systems.

The modern outlook in AI simultaneously offers an overview of financial aspects, the application of intelligence, financial challenges, and the AI methods employed to address historical and current financial issues as elaborated by Cao (2018).

Table 2: AI in finance: A modern look: Cao (2018)

Financial Area	Finance Look	AI in Finance Look	Financial Problems	AI Techniques for handling and reform in finance
	Insurance Management, Wealth and Property Management, Foreign Exchange Market Management and Energy Management	AI: As a Smart Alternative Finance	<ul style="list-style-type: none"> · Property Valuation and Estimation · Site Selection and Evaluation · Property Policies rules and Governance · Supply and Demand · Property Optimization, · Insurance Services and Products for Selections · Pricing and Market Positioning for Insurance · Risk Management, · Market: Personalization, Recommendation, and Customization, · Predicting Currency Rating and Exchange Rate, · Discovering the wealth of People, Change and New Requirements, etc. 	<ul style="list-style-type: none"> · Text Analysis · Social Media Analysis · Behaviour Analysis · Simulation Theory · Profiling Method · Statistical Learning · Numerical Computational · Knowledge Discovery and Evaluation · Data Mining · Mathematical Modelling · Risk Analytics · Deep Learning · Artificial Neural Network · Model and Multi-Source Analysis · Multivariate Time Series · Dependence Modelling · Optimization Method · Event Analysis · Sentiment Analysis · Active and Intent Learning.

<p>(ii). Financial Market</p>	<p>Cross Market Analysis and Micro and Macro Economic Market Performance Analysis</p>	<p>Global and Cross-Market Performance and Analysis</p>	<ul style="list-style-type: none"> · Micro/ Macro Financial Variables and Modelling Testing · Analysing and Coupling Interactions and Relations between Economics, · Influencing Level and Movements, · Cultural and Political issues between Financial Variables · Derivatives, Regions · Companies Performance · Financial Indicators in social culture and economic factors · Countries Indicators etc. 	<ul style="list-style-type: none"> · Machine Learning · Statistical Modelling · Mathematical Modelling · Multisource Analysis · Behaviour Analytics · Event Analysis · Hybrid Methods · Relation Learning Method · Coupling Learning · Interaction Learning Technique · Multivariate Analysis · Sequence Modelling, etc.
<p>(iii). E-Financing</p>	<p>Smart Banking and e-Payment, Artificial Intelligent e-commerce, Internet Banking and finance</p>	<p>Artificial Intelligent Online Banking, Mobile, IoT based and Internet Finance</p>	<ul style="list-style-type: none"> · Risk Fraud & Security Issues, · Online Market Demand & Supply, · Online Financial Products and Services, · Estimation & Prediction, · Online Marketing, · Delivery, Storage, · Online Mobile Payment and Support, · Secure Fund, · Online Insurance, Automation, and Online Banking, · Online Fraud and · Internet-based Services, etc. 	<ul style="list-style-type: none"> · Risk Analytics, · Behaviour Analytics · User Modelling · Social Media Analysis Technique · Web Analysis · Profiling Technique · Text Analysis · Predictive Modelling · Network Analysis · Deep Learning · Trajectory Modelling · Machine Learning and Data Mining

				<ul style="list-style-type: none"> · Online Web Analysis · Security Informatics · Recommender System, etc.
(iv). Financial Modelling	Blockchain Systems, Security & Mechanisms	Artificial Intelligent Blockchain	<ul style="list-style-type: none"> · Blockchain Modelling and Financial System, · Risk Averse and Anti Attack Blockchain, · Optimizing Portfolio and Product Pricing, · Blockchain Mechanisms, · Evaluating and Use Bitcoin, · Cryptographic Contact Model, · Enabling Secure, Smart Contract, · Privacy, Detecting and Mitigating · Malicious Attacks and Criminal Activity, · Governance and Regulation, etc. 	<ul style="list-style-type: none"> · Supervised and Unsupervised Learning · Fraud Detection Analysis · Process Analysis · Event Analysis Technique · Agent-Based Learning · Game Theories · Risk Analysis · Representation Learning · Online Learning · Machine Learning and Deep Learning · Theories of Complex System Method · Change Detection · Behaviour Analysis · Benchmarking · Outlier Detection · Semantic Web · Prediction and Optimization Technique, etc.

(v). Financial System	Corporate Financing and Smart Operations & Regulation	Favourable & Optimal Governance, Operations, Regulation	<ul style="list-style-type: none"> · Corporate Governance and Regulation · Performance Issues, Problems of Risk and Loss in Operations & Governance, · Discovering Factors, Operation · Simultaneously Financial Regulation and Performance issues · Payment and Fraud issues, · Financial Balancing, etc. · 	<ul style="list-style-type: none"> · Financial Time Series Analysis · Behaviour Analysis · Interactional Modelling · Risk Analysis Method · Multisource/ Model Analysis · Process Analysis · Relation Modelling and Learning · Probabilistic and Supervised and Unsupervised Learning · Event Analysis · Representation Learning · Anomaly Detection Method, etc.
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10. Benefits of AI in finance

Following the integration of AI in finance, work becomes more streamlined, resulting in optimized decision-making. The advantages of Artificial Intelligence in the financial sector are as follows:

- i. Automation of Tasks: AI enables the automatic execution of tasks upon command.
- ii. Identification of Financial Errors: It aids in the detection of financial mistakes and can also identify instances of financial fraud when they occur.
- iii. Problem Solving: AI-driven machines offer solutions to financial issues and provide recommendations for their resolution through AI techniques.
- iv. Enhanced Security for Funds: AI in finance significantly enhances the safety of funds and financial transactions.
- v. 24/7 Service Availability: After implementation, AI systems provide services around the clock and assist with customer services and interactions.
- vi. Streamlined Processes: Machines carry out tasks smoothly and efficiently, eliminating the need for repetitive work.
- vii. Intelligent Work: This technology transforms arduous tasks into smarter, more efficient processes.
- viii. Reduced Human Error: AI processes financial data rapidly and accurately, resulting in fewer human errors.

11. Conclusions

The research's findings highlight the positive AI trends that are enhancing transactions and decisions, reducing errors, and benefiting both the general public and corporate finances. This study has introduced digital platforms that are accessible to individuals and businesses, facilitating seamless personal financial planning. Future research should strive to make more informed decisions concerning financial objectives and create AI-driven financial plans. Subsequent studies should concentrate on streamlining decision-making procedures and devising intelligent investment strategies tailored to individuals' income levels. Hence, it is clear that AI proves beneficial in a wide range of scenarios and is adept at efficiently handling various financial tasks.

12. Future of Artificial Intelligence in finance

Machines are poised to assume roles in decision-making, task execution, efficient time management, adherence to instructions, protection of financial assets, prudent financial decision-making, flawless task execution, and the performance of error-free functions. AI forecasts are set to find utility within the realm of financial services, instigating a transformative and innovative shift in financial operations across various sectors, including banking, non-banking entities, financial advisory, financial markets, credit rating agencies, customer relations and interactions, and more.

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