



Artificial Intelligence, Machine Learning, Deep Learning, and Blockchain in Financial and Banking Services: A Comprehensive Review

Mallikarjuna Paramesha¹, Nitin Liladhar Rane², Jayesh Rane³

¹Construction Management, California State University, Fresno, USA.

^{2,3}University of Mumbai, Mumbai, India.

Abstract –This research offers a thorough overview of the current research on artificial intelligence, machine learning, deep learning, and blockchain applications in the financial and banking industries, emphasizing the notable influence these technologies have had on spurring innovation and enhancing operational effectiveness. The research landscape is defined by key themes and trends through a detailed analysis of keyword co-occurrence and clusters in the study. The results highlight the important role of artificial intelligence in improving decision-making abilities, promoting innovation in financial markets, creating sophisticated trading strategies, and maintaining strong cybersecurity measures. Support vector machines and neural networks are more frequently utilized in predictive modeling, fraud detection, and portfolio management. Sophisticated data analysis tasks benefit from deep learning techniques like convolutional neural networks and long short-term memory networks, providing a more in-depth understanding of market trends and customer behaviors. Blockchain technology, known for its decentralized and transparent features, has become a crucial element in fintech advancements, guaranteeing secure and efficient transaction processing, ultimately building trust and minimizing the threat of fraud. The research also points out the merging of AI and blockchain, which is driving the creation of new financial products and services and encouraging digital transformation in the industry. Moreover, the research delves into the possibilities of new technologies such as quantum computing in solving intricate computational problems in the financial sector, including portfolio optimization, risk management, and cryptography. The research contributes by outlining key research topics, offering perspectives on various AI methods and uses, and proposing new research paths for exploring AI's integration in finance and banking.

Keywords: Artificial Intelligence, Deep Learning, Finance, Banking, Machine Learning, Forecasting, ChatGPT, Blockchain.

1. INTRODUCTION

The swift progress of artificial intelligence (AI) has greatly changed many industries, with the financial and banking fields being some of the most affected. AI technologies, such as machine learning, deep learning, and blockchain, have transformed conventional financial procedures with more effective, precise, and secure approaches to analyzing data, evaluating risks, and processing transactions[1]. The use of AI in finance has not just made operations more efficient but also boosted decision-making abilities, allowing financial institutions to provide tailored services and enhance customer satisfaction. Recent research has emphasized the ability of artificial intelligence to promote innovation in financial markets, aid in creating advanced trading techniques, and guarantee strong cybersecurity measures. Support vector machines and neural networks are being more commonly relied upon for tasks like predictive modeling, fraud detection, and managing portfolios[2]. Advanced methods of deep learning, such as convolutional neural



networks and long short-term memory networks, are utilized for intricate data analysis, providing a more profound understanding of market patterns and consumer actions. Blockchain technology, known for its decentralization and transparency, has become a crucial element of financial technology advancements. It guarantees the safe and effective handling of transactions, thus building trust and diminishing the possibility of fraud. The blending of artificial intelligence and blockchain technology is driving the creation of new financial products and services, advancing digital transformation in the industry. The purpose of this paper is to offer a thorough analysis of the current research on utilizing AI in the financial and banking sectors. Through the use of keyword co-occurrence and cluster analysis, we pinpoint essential topics and patterns that characterize the present research environment. This examination provides a thorough comprehension of the interconnectedness of AI technologies and their thematic groupings in the financial sector[3-4].

Our contributions to the field are as follows:

- We map out the central themes in AI applications within finance and banking through co-occurrence and cluster analysis, highlighting the predominant research areas.
- We provide an in-depth discussion of various AI techniques, such as machine learning and blockchain, and their specific applications in financial services.
- Based on our findings, we suggest potential areas for future research to further explore the integration of AI in finance and banking, addressing emerging challenges and opportunities.

2. METHODOLOGY

This thorough examination uses a structured approach to evaluate how artificial intelligence is used in financial and banking services. The main sources of information for this evaluation consist of scholarly articles, conference materials, and industry reports collected from respected academic databases like IEEE Xplore, Google Scholar, and Scopus. A combination of AI-related keywords like "artificial intelligence," "machine learning," "deep learning," "blockchain," "financial services," and "banking" was utilized in the literature search for AI applications in finance. To guarantee a comprehensive and fair evaluation, we implemented a two-step approach for gathering and analyzing data. Initially, we performed a keyword search to find relevant literature that has been published in the last ten years. The first search results were then refined by relevance, choosing only articles that focused on the application of AI technologies in financial and banking settings for further study. The chosen literature was then analyzed in detail for co-occurrence and clustering using VOSviewer, a software tool created for constructing and visualizing bibliometric networks. Analysis of co-occurrence was utilized to detect the frequency of specific keywords appearing together in literature, revealing relationships and connections among various AI technologies and their uses. This examination assisted in outlining the primary themes and sub-themes found in the research area. Cluster analysis was utilized to categorize related keywords into thematic clusters, offering a visual depiction of the main areas of emphasis in the present literature. Every group was examined to comprehend the main research subjects and the particular AI methods and uses being investigated in each category. This methodology enabled us to acquire a thorough comprehension of the AI applications in the financial and banking services landscape, emphasizing key research areas and pinpointing potential areas for future investigation.



3. RESULTS AND DISCUSSION

Co-occurrence and cluster analysis of the keywords

The co-occurrence and cluster analysis (Fig. 1) of keywords provide a detailed understanding of the interconnections and thematic clusters within the research domain. The central theme in the network is "artificial intelligence," which serves as the hub connecting various related keywords. This central positioning highlights AI's pivotal role across multiple aspects of financial and banking services. Surrounding this hub are key terms like "machine learning," "deep learning," "big data," "blockchain," "financial services," "banking," and "sustainability." These keywords reflect the core areas where AI technologies are applied and researched. "Machine learning" is closely linked with keywords such as "neural networks," "support vector machines," "decision trees," and "logistic regression." These associations highlight the prevalent machine learning techniques used in financial applications, emphasizing the importance of predictive modeling and classification tasks. Similarly, "deep learning" is connected with "convolutional neural networks" and "long short-term memory," showcasing advanced neural network architectures employed for complex data analysis in finance. "Big data" and "blockchain" form another significant cluster, underscoring the critical role of data management and secure transactions in modern financial systems. The connections between "big data," "information management," and "Internet of things" (IoT) illustrate the integration of vast amounts of data from diverse sources to enhance decision-making processes and operational efficiencies in banking.

Cluster Analysis

Machine learning and decision support systems:

This cluster includes keywords such as "machine learning," "learning systems," "support vector machines," "decision trees," "regression analysis," "feature selection," and "credit risk." The focus here is on developing robust algorithms to support decision-making processes in financial institutions. The prominence of "risk assessment," "forecasting," and "time series" analysis within this cluster signifies the emphasis on predictive analytics to manage financial risks and forecast market trends.

Financial markets and trading:

Keywords like "financial markets," "electronic trading," "neural networks," "genetic algorithms," and "optimization" dominate this cluster. This grouping highlights the application of AI in trading strategies, market analysis, and algorithmic trading. The interconnections between "profitability," "forecasting," and "commerce" suggest a focus on enhancing trading outcomes and market efficiency through AI-driven insights.

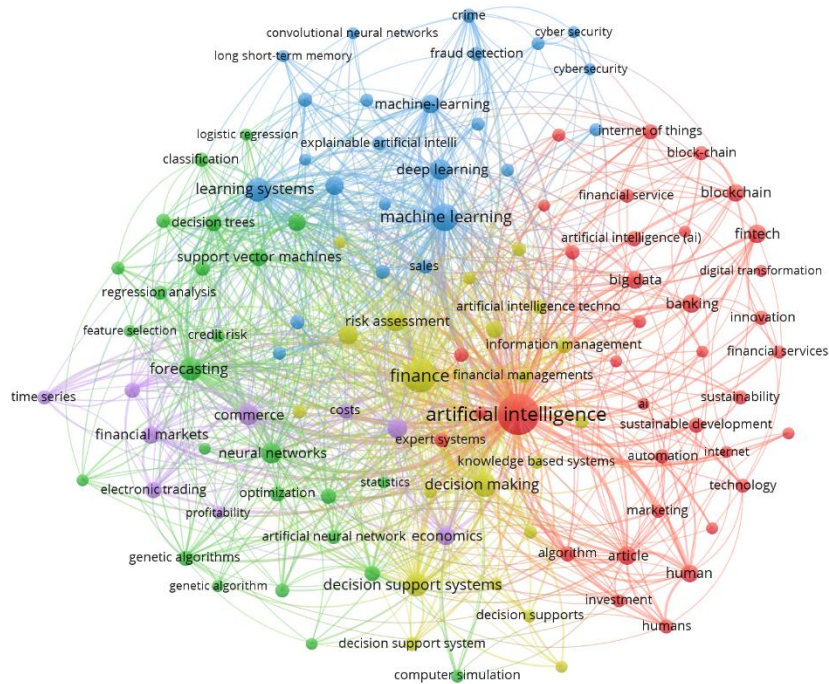


Fig -1: Co-occurrence analysis of the keywords in the literature

Blockchain and fintech:

This cluster is characterized by keywords such as "blockchain," "fintech," "digital transformation," "banking," "innovation," "financial services," and "sustainability." The cluster underscores the transformative impact of blockchain technology and fintech innovations on traditional banking and financial services. The links between "sustainability," "automation," and "internet" point towards the growing importance of sustainable practices and automated solutions in the financial sector.

AI in decision-making and knowledge systems:

Central to this cluster are keywords like "artificial intelligence," "decision making," "knowledge-based systems," "expert systems," "statistics," and "economics." This grouping emphasizes the role of AI in enhancing decision-making processes and developing intelligent systems capable of supporting complex financial decisions. The connections to "algorithm," "article," and "investment" suggest a scholarly focus on the theoretical and practical applications of AI in financial investments and economic modeling.

Cybersecurity and fraud detection:

Keywords such as "cybersecurity," "fraud detection," "crime," and "explainable artificial intelligence" form a distinct cluster, reflecting the critical importance of AI in safeguarding financial systems against cyber threats and fraudulent activities. The inclusion of "convolutional neural networks" within this cluster indicates the use of advanced AI techniques to detect and prevent security breaches.

4. ARTIFICIAL INTELLIGENCE APPLICATIONS IN BANKING

AI has become a key factor in changing banking services and improving efficiency, customer experience, and security measures. A major use of AI in banking is in customer service, with AI chatbots and virtual assistants managing everyday queries, offering tailored financial guidance, and aiding in transactions,



allowing staff to focus on more intricate duties. These artificial intelligence systems use algorithms for machine learning and natural language processing to address customer needs quickly and accurately[5]. AI is transforming fraud detection and cybersecurity within the banking industry as well. Sophisticated machine learning models examine large amounts of transaction data in real time to detect abnormal patterns and possible fraudulent behaviors. These systems can promptly identify questionable transactions, decreasing the chance of fraud and boosting the safety of banking activities. Furthermore, advanced security measures driven by AI, like biometric verification and behavior analysis, are becoming more common, adding an extra level of security for customers' financial information. AI models are used in credit risk assessment to assess the creditworthiness of individuals applying for loans[6]. AI systems can offer more precise and detailed evaluations than traditional methods by examining various data points such as credit history, transaction behavior, and social media activity. This not only improves loan decision-making but also guarantees that credit is offered to a wider range of people, such as those without traditional credit records.

Artificial intelligence is also contributing significantly to improving operational effectiveness in banks. Robotic process automation (RPA) is employed for automating tasks that are repetitive and consume a lot of time, including data entry, compliance checks, and report generation. This mechanization decreases operational expenses, reduces mistakes, and permits human workers to concentrate on higher-level and beneficial tasks. Furthermore, AI-driven predictive analytics assists banks in predicting market trends, improving investment strategies, and effectively managing risks. AI is making substantial progress in customizing banking experiences. Banks can provide personalized financial products and services based on individual customer preferences and behaviors through the use of data analytics and machine learning[7-8]. This customization also applies to focused marketing initiatives, rewards schemes, and personalized financial recommendations, improving customer contentment and allegiance. Moreover, the blending of AI with blockchain technology is creating fresh opportunities for trustworthy and transparent financial transactions[9]. AI algorithms drive smart contracts to automate agreement execution when specific conditions are fulfilled, cutting out middlemen and enhancing transaction speed and reliability. The collaboration between AI and blockchain is especially advantageous for international payments, financing trade, and managing supply chains. Overall, AI's role in banking is varied, contributing to innovation in different areas of the sector. AI is transforming the banking industry by improving customer service, increasing security, streamlining operations, and providing more personalized financial services.

5. ARTIFICIAL INTELLIGENCE APPLICATIONS IN FINANCIAL SERVICES

Artificial intelligence (AI) is fundamentally changing financial services by providing creative solutions that improve efficiency, precision, and customer satisfaction throughout the industry. One significant use of AI in the financial industry is in managing investments. AI algorithms examine extensive datasets to recognize patterns and trends, allowing financial advisors and investors to make better-informed choices. These algorithms can analyze intricate financial data at a quicker pace and with greater precision compared to humans, ultimately improving portfolio management, forecasting analytics, and risk evaluation. AI is transforming the way financial institutions manage regulatory compliance and risk management[10]. Regulatory technologies, also known as RegTech, utilize artificial intelligence to streamline compliance procedures, oversee transactions for any irregularities, and verify compliance with regulatory standards. This automation decreases the time and money required for compliance tasks, while also reducing the chances of human mistakes. Machine learning models can constantly learn from fresh data, enhancing

their ability to identify potential compliance problems and financial crimes, including money laundering and insider trading. Fig 1. Shows the artificial intelligence applications in financial services.

In customer service, AI-driven tools are improving the client experience through customized and effective interactions. Virtual financial advisors and chatbots can respond to customer questions, provide financial guidance, and carry out transactions. AI-driven interfaces utilize natural language processing to comprehend and address customer requirements, delivering a personalized and smooth user experience. This enhances customer contentment and enables financial service providers to assist more clients more efficiently. AI is currently being employed to enhance credit scoring and loan approval processes[11]. Conventional credit scoring models frequently depend on a restricted range of financial criteria, potentially leading to the exclusion of individuals with unconventional financial backgrounds. AI can examine a wider range of data points, such as transaction history, social media activity, and mobile phone usage patterns. This comprehensive strategy allows for more precise evaluations of creditworthiness, increasing access to credit for marginalized groups and enhancing the accuracy of lending decisions.

AI technologies like machine learning and deep learning are utilized in trading and market analysis to create advanced trading algorithms. These algorithms are capable of examining market data instantly, discovering trading chances, and carrying out trades at the most favorable moments[12]. AI is utilized by high-frequency trading platforms to quickly analyze massive amounts of data, allowing them to outperform rivals in the market. Furthermore, AI models are employed to analyze sentiment and interpret news articles, social media posts, and other text data to understand market sentiment and advise trading strategies. It is playing a major role in making important contributions in the fields of fraud detection and cybersecurity. Financial institutions are using AI to spot and stop fraudulent activities by examining transaction patterns and pinpointing abnormalities in real time. AI systems can detect even the smallest variations in normal behavior, allowing for quick reactions to possible dangers. This proactive strategy boosts both security and safeguards the financial integrity of institutions and their clients. To sum up, AI is leading significant progress in financial services through streamlining investment management, boosting compliance and risk control, enhancing customer service, refining credit assessment, transforming trading methods, and strengthening fraud identification. These applications are changing the sector by improving the efficiency, security, and accessibility of financial services, resulting in improved outcomes for institutions and their clients[13-14].

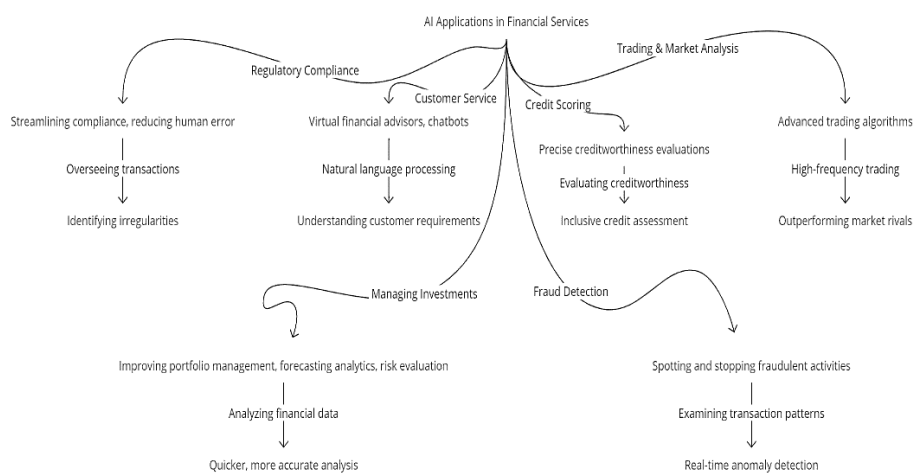


Fig -1: Artificial intelligence applications in financial services



6. MACHINE LEARNING AND DEEP LEARNING IN FINANCE AND BANKING SERVICES

Machine learning and deep learning are leading the technological revolution in finance and banking services, bringing about notable enhancements in predictive analytics, risk management, customer service, and operational efficiency. Machine learning is a branch of artificial intelligence that focuses on creating algorithms that enable computers to learn from data and make decisions[15,32]. In the field of finance, these algorithms are widely utilized for predictive modeling, including predicting stock prices, evaluating credit risk, and spotting investment chances. Through the examination of past data and identification of patterns, machine learning algorithms can forecast future trends accurately, helping financial institutions enhance strategic planning and decision-making. Deep learning, a more evolved form of machine learning, utilizes neural networks containing numerous layers to analyze intricate data sets and derive significant interpretations. This technology is especially useful in fields that involve analyzing high-dimensional data, like fraud detection and algorithmic trading. Deep learning models in fraud detection analyze large sets of transaction data to pinpoint suspicious patterns and anomalies that may suggest fraudulent behavior[16]. These models keep learning from fresh data to enhance their capability in real-time fraud detection, minimizing the chances of financial losses. In the field of customer service, banks are changing the way they communicate with customers using machine learning and deep learning technologies. Chatbots and virtual assistants utilize artificial intelligence to comprehend and answer customer questions through natural language processing, delivering fast and precise responses. These systems can manage various tasks, ranging from responding to frequently asked questions to carrying out intricate transactions, ultimately boosting customer satisfaction and lessening the workload of human employees[18]. Table 1. Shows machine learning and deep learning in finance and banking services.

Machine learning and deep learning technologies have greatly enhanced credit scoring and loan approval procedures. Conventional credit scoring systems frequently depend on a restricted range of financial indicators, resulting in the exclusion of potential borrowers with limited credit backgrounds. Machine learning models can evaluate a wider range of data points, such as social media interactions, transaction patterns, and smartphone usage habits. This allows for more precise and equitable evaluations of creditworthiness, increasing credit availability for marginalized communities and enhancing the accuracy of loan decisions[19–20]. Deep learning algorithms are employed in trading and market analysis to create advanced trading strategies. These algorithms can analyze large quantities of market data instantly, detecting patterns and forecasting price changes. High-frequency trading platforms use deep learning to make trades at the best times, increasing profits and gaining an edge over competitors. Additionally, with the support of deep learning, sentiment analysis analyzes news articles, social media posts, and other text data to measure market sentiment and guide trading choices. Machine learning and deep learning are improving operational efficiency in banks by automating routine tasks[21–22]. Robotic process automation (RPA) utilizes these technologies to carry out repetitive tasks like data entry, compliance checks, and report generation, resulting in decreased errors and lower operational expenses. This technology enables human workers to concentrate on higher-level and more beneficial tasks, ultimately enhancing productivity and efficiency. In conclusion, machine learning and deep learning are leading to revolutionary advancements in finance and banking services. These technologies are increasing efficiency, security, and responsiveness in financial institutions by improving predictive analytics, risk management, customer service, and automating operations. The financial sector is anticipated to experience increasing influence as these technologies develop further, leading to a fresh era of innovation and growth[23–24].

Table -1: Machine learning and deep learning in finance and banking services.



Sr. No.	Aspect	Machine Learning Applications	Deep Learning Applications
1	Predictive Analytics	Predicting stock prices, credit risk, and investment opportunities	Fraud detection, algorithmic trading
2	Risk Management	Predictive modelling for future trends	Real-time fraud detection
3	Customer Service	Chatbots and virtual assistants for customer queries	Natural language processing for customer interaction
4	Credit Scoring and Loan Approval	Evaluating wider data points for creditworthiness	Accurate and equitable loan decisions
5	Trading and Market Analysis	Advanced trading strategies using market data	Sentiment analysis of news and social media
6	Operational Efficiency	Robotic process automation for routine tasks	Automation of repetitive tasks, improving productivity

7. CHATGPT IN FINANCE AND BANKING SERVICES

ChatGPT, a sophisticated language model created by OpenAI, is becoming widely adopted in finance and banking industries, providing various tools to improve customer engagement, simplify tasks, and aid in decision-making. In banking, ChatGPT is commonly utilized in customer service to act as a virtual assistant that can manage various customer queries. By utilizing natural language processing, ChatGPT can comprehend and address customer inquiries immediately, offering precise answers and remedies for typical banking problems[25–26]. This ability greatly cuts down on customer wait times and enables human representatives to concentrate on more intricate issues that demand a personal approach. Furthermore, ChatGPT is being used to provide personalized financial advice, in addition to enhancing customer service. By examining a customer’s history of transactions, patterns of spending, and financial objectives, personalized guidance can be provided on budgeting, saving, and opportunities for investing[27]. This amount of customization assists customers in making better financial choices, improving their overall banking journey. Additionally, ChatGPT can help new customers with the onboarding process by walking them through setting up their accounts, clarifying the functionalities of various financial products, and making sure all required paperwork is filled out correctly and promptly. An essential use of ChatGPT in the financial sector is in identifying and stopping fraudulent activities. ChatGPT can detect unusual patterns and alert potentially fraudulent activities by monitoring transaction data and communication logs. Financial institutions can quickly address threats by processing and analyzing large amounts of data in real time, resulting in reduced fraud risk and better protection of customer assets. Furthermore, ChatGPT can also be utilized for compliance monitoring to help financial institutions comply with regulations by analyzing transactions and flagging any unusual activities[28]. Fig 2. Shows the ChatGPT in finance and banking services.

Within internal operations, ChatGPT is utilized for automating regular tasks like creating financial reports, handling schedules, and performing market research. Banking professionals can save time by synthesizing information from different sources and presenting it coherently, which lets them concentrate on strategic initiatives[29]. Moreover, ChatGPT assists in decision-making by offering insights and recommendations from historical data and predictive analytics, aiding financial institutions in navigating intricate market conditions and making well-informed strategic choices. Furthermore, ChatGPT is improving the skills of financial advisors by serving as a smart aide that can swiftly access data, evaluate client portfolios, and

recommend the best investment strategies. This assistance allows advisors to offer clients more thorough and evidence-based guidance[30]. ChatGPT is capable of being incorporated into platforms for financial education, aiding users in comprehending intricate financial ideas, monitoring their financial objectives, and keeping up to date with current market trends and regulatory adjustments. In general, ChatGPT is transforming the finance and banking industries through bettering customer service, boosting operational efficiency, and backing important decision-making processes. Financial institutions benefit from their valuable capacity to process natural language and produce human-like responses, enabling them to offer exceptional service while driving innovation. As technology advances, ChatGPT's potential in the finance sector is projected to grow, leading to more progress and improvements in the field[31].



Fig -2: ChatGPT in finance and banking services

8. ROBOTIC PROCESS AUTOMATION (RPA) IN FINANCE AND BANKING SERVICES

Robotic Process Automation (RPA) is changing the finance and banking industries by automating repetitive and mundane tasks, improving efficiency, accuracy, and operational flexibility. RPA uses software robots, also known as "bots," to imitate human actions on digital systems, carrying out tasks like data input, transaction processing, compliance checks, and generating reports[32]. Automating these time-consuming tasks through RPA helps decrease the time and money spent on manual operations and lowers the chance of human error. In banking, the processing of transactions is a key area where RPA is commonly utilized. Bots can manage large amounts of transactions quickly and accurately, guaranteeing that payments, transfers, and other financial activities are completed with precision and speed. This automation enhances both transaction efficiency and customer satisfaction by reducing delays and errors. Furthermore, RPA is capable of reconciling accounts and handling exceptions, swiftly pinpointing and fixing errors to ensure precise financial records[33]. RPA is also crucial for ensuring regulatory compliance, a critical part of banking activities. Financial institutions must follow numerous regulations and reporting standards, which are intricate and can take up a lot of time. RPA simplifies compliance procedures through the automation of collecting, processing, and reporting necessary data for regulatory submissions. This guarantees that compliance tasks are carried out uniformly and precisely, decreasing the possibility of non-compliance and related fines. Bots can oversee transactions to detect any suspicious behaviors, helping in the fight against money laundering by identifying possibly fraudulent transactions for additional scrutiny[34–35].



RPA provides considerable advantages in the customer onboarding process. The process of bringing in new customers includes various stages such as verifying their identity, conducting background checks, and collecting required documents. RPA speeds up these steps, making the onboarding process faster and ensuring compliance with regulations. This automation enhances customer satisfaction by decreasing waiting times and streamlining the account setup procedure, facilitating customer access to banking services[36]. RPA not only improves operational efficiency and compliance but also enhances decision-making and strategic planning. Automating financial reports and dashboard generation through RPA gives banking executives timely and precise insights into the organization's performance. This immediate access to crucial information aids in making more informed choices and improving strategic planning effectiveness. Moreover, RPA can connect with additional technologies like artificial intelligence and machine learning, to offer predictive analytics and detect upcoming trends, allowing for proactive management of risks and opportunities[37]. RPA is also advantageous for back-office tasks in banks such as loan processing and mortgage origination. Bots are capable of managing document authentication, conducting credit evaluations, and inputting data, which speeds up the approval procedure and enhances precision. This not only boosts efficiency in operations but also enhances the customer experience by decreasing the time needed to handle loan and mortgage applications [38]. RPA is transforming finance and banking services by automating everyday tasks, improving precision, and allowing human resources to focus on more strategic tasks. RPA is an invaluable tool for financial institutions looking to remain competitive in a fast-changing industry by enhancing operational efficiency, ensuring compliance, and aiding in decision-making. With the progression of RPA technology, its utilization in the finance and banking industries is projected to grow, leading to increased efficiencies and innovations in the sector[39].

9. BLOCKCHAIN AND AI INTEGRATION IN FINANCE AND BANKING SERVICES

The merging of blockchain and artificial intelligence (AI) is leading a new age in finance and banking services, leveraging the advantages of both technologies to develop safer, faster, and more creative financial options. Blockchain, well-known for its decentralized and unchangeable record, provides unmatched transparency and security for transactions[40]. Artificial intelligence, with its advanced abilities in processing data and analysis, improves decision-making and operational effectiveness. These technologies are changing different parts of the financial sector, including transaction processing and fraud detection. Blockchain and AI integration play a major role in improving transaction processing by boosting security and efficiency. The decentralized ledger of blockchain guarantees that every transaction is documented transparently and securely, minimizing the chances of fraud and mistakes. AI algorithms can examine transaction information instantly, detecting unusual patterns and potential fraud cases. This merging allows financial institutions to identify and stop fraud with better results, safeguarding the trustworthiness of financial transactions[41-42]. Additionally, the combination of blockchain and AI is transforming how financial services handle and employ data. Blockchain offers a safe and open platform for storing large quantities of financial information, with AI algorithms able to analyze the data and reveal important insights and trends. For example, AI can forecast market trends and consumer actions through the examination of past transaction data kept on the blockchain. Financial institutions can benefit from this ability to predict future outcomes, enabling them to make better decisions, improve investment strategies, and provide tailored financial products and services. Smart contracts, driven by blockchain technology and bolstered by artificial intelligence, represent another revolutionary use case in the financial industry[43]. Self-enforcing contracts enact the agreement's terms automatically upon meeting specific conditions. AI can be utilized to oversee the terms and factors of these agreements, making sure they are carried out correctly and effectively.



When it comes to regulatory compliance, combining blockchain and AI provides notable benefits. The transparent ledger of blockchain enables financial institutions to easily comply with regulatory requirements by providing a reliable audit trail for all financial transactions[44]. AI can automate the supervision and documentation of compliance-related tasks, guaranteeing that financial institutions follow changing regulations. This mix decreases both the duration and expenses linked to meeting requirements, while also lowering the chances of violating regulations. Moreover, the incorporation of blockchain and AI is boosting the functionalities of digital identity authentication[45]. Blockchain offers a reliable and unchangeable database of identity details, as AI algorithms can promptly and precisely examine and validate this data. This integration simplifies the process of welcoming new customers, boosts security, and lowers the chance of identity theft and fraud. It also allows financial institutions to provide their customers with digital services that are both secure and smooth[46]. Moreover, the combination of blockchain and AI is spurring innovation in the realm of decentralized finance (DeFi). DeFi platforms utilize blockchain technology to establish financial systems that are both transparent and accessible, functioning without the need for traditional intermediaries. AI improves these platforms by offering sophisticated analytics, risk management, and automated decision-making features. This mix is increasing the availability of financial services, supporting financial inclusivity, and allowing for the development of innovative financial products and services[47–48]. In short, the combination of blockchain and AI in finance and banking is driving a fresh wave of innovation and productivity. By bolstering transaction security, enhancing data management, automating compliance, and introducing new financial products, this strong amalgamation is transforming the financial industry. As these technologies progress further, their combined integration is expected to result in additional revolutionary changes within the industry, providing substantial advantages to both financial institutions and their clients[49].

Table -2: Blockchain and AI integration in finance and banking services

Sr. No.	Aspect	Blockchain Applications	AI Applications
1	Transaction Processing	Decentralized and secure ledger for transactions	Instant analysis of transaction data for fraud detection
2	Data Management	Secure and transparent platform for storing financial data	Analysis of stored data to reveal insights and trends
3	Predictive Analytics	Secure historical data storage	Forecasting market trends and consumer behavior
4	Smart Contracts	Self-enforcing contracts	Monitoring and executing contract terms
5	Regulatory Compliance	Reliable audit trail for transactions	Automating supervision and documentation of compliance tasks
6	Digital Identity Authentication	Immutable database of identity details	Fast and accurate verification of identity data
7	Decentralized Finance (DeFi)	Transparent and accessible financial systems	Advanced analytics, risk management, and automated decision-making
8	Innovation and Productivity	Enhancing transaction security and new financial products	Improving decision-making and operational efficiency



10. QUANTUM COMPUTING APPLICATIONS IN FINANCE AND BANKING SERVICES

Quantum computing has the potential to transform the financial and banking industry with its extraordinary computational abilities, providing solutions to intricate problems that are currently unsolvable by traditional computers. Quantum computers use quantum mechanics principles like superposition and entanglement to conduct calculations much quicker than regular computers. This vast processing power creates opportunities for new ideas and improvements in different aspects of the financial industry. Portfolio optimization is a highly promising use of quantum computing in the field of finance[50]. The classical method of optimizing a portfolio includes managing risk and returns among various assets, which becomes more challenging as the portfolio grows in size. Quantum algorithms like QAOA can effectively deal with these complexities, leading to improved and quicker optimization of vast portfolios. This could result in improved investment approaches and increased financial gains for asset managers and investors[51].

Quantum computing could greatly impact risk management, an important field. Financial institutions need to assess and minimize various types of risk including market risk, credit risk, and operational risk. Quantum computing can enhance risk analysis through its capability to process vast amounts of data and conduct numerous simulations for more accurate risk predictions. This improved capacity to evaluate risk helps financial institutions be better prepared for adverse market conditions and in developing more robust risk mitigation strategies[52]. In the field of financial cryptography, quantum computing presents both obstacles and possibilities. Although quantum computing endangers current cryptographic techniques like RSA and ECC by its ability to decrypt these codes, it also spurs the creation of quantum-resistant cryptographic algorithms. Financial institutions are putting money into research for the creation and application of new cryptographic methods to protect sensitive financial information from potential quantum threats in the future. Quantum key distribution (QKD) is a cutting-edge technique that relies on the principles of quantum mechanics to ensure the safety of financial transactions. Quantum computing is anticipated to transform high-frequency trading (HFT) by improving trading strategies and carrying out trades at extraordinary speeds[53]. Quantum algorithms can analyze market information instantly, recognizing trading chances and conducting transactions more swiftly compared to conventional algorithms. This quickness and effectiveness can provide traders with a notable edge in the high-speed environment of financial markets, where even milliseconds can greatly impact profitability.

Additionally, quantum computing has the potential to improve fraud detection and bolster cybersecurity efforts within the financial industry. Quantum algorithms are better at identifying anomalies and potential fraud in transaction data compared to classical systems due to their ability to analyze complex patterns more efficiently[54]. Financial institutions can better safeguard their assets and customer data from cyber threats and fraudulent activities thanks to this improved detection ability. Moreover, quantum computing can also improve the precise and efficient valuation of intricate financial products like derivatives. Quantum algorithms can simulate how these instruments perform in different market situations[55], leading to more accurate evaluations and risk evaluations. This capability is extremely useful for financial institutions that handle a large number of intricate derivatives and need precise pricing models to effectively oversee their portfolios. In general, incorporating quantum computing into finance and banking has the potential to revolutionize the sector by offering solutions to challenging issues, boosting security, and streamlining financial operations. With the continuous advancement of quantum technology, new opportunities are expected to be unlocked in the financial sector, which will drive more innovation leading to improved efficiency, security, and effectiveness of financial services[56].



11. CONCLUSIONS

The incorporation of artificial intelligence (AI) into financial and banking sectors is leading to a significant change, marked by greater efficiency, heightened security, and enhanced customer satisfaction. AI technologies such as machine learning, deep learning, and blockchain are transforming old methods by offering advanced tools for analyzing data, assessing risks, and processing transactions. This review has pointed out the major impacts of AI in different fields, including fraud detection, credit scoring, personalized financial services, and high-frequency trading. Machine learning and deep learning algorithms are leading the way in predictive analytics, allowing financial institutions to predict market trends, improve investment strategies, and enhance customer service using smart chatbots and virtual assistants. The secure and transparent ledger of blockchain technology works in harmony with AI to guarantee the integrity and efficiency of financial transactions. The collaboration between AI and blockchain is prominently seen in the advancement of smart contracts and decentralized finance platforms, aiming to make financial services more accessible and promote financial inclusivity. Robotic Process Automation (RPA) simplifies operational procedures by automating repetitive duties, thereby cutting costs, and reducing human mistakes. In the meantime, the emergence of quantum computing can tackle intricate computational tasks in finance like portfolio optimization, risk management, and cryptography. With the advancement of quantum technology, it is anticipated that AI will be able to improve financial systems by making them stronger and more reliable. This in-depth analysis highlights how AI plays a crucial part in boosting innovation and productivity in the financial industry. Financial institutions can enhance their capability to navigate modern market complexities, enhance regulatory compliance, and provide clients with more personalized and secure services by utilizing advanced AI methods. The results of this study also suggest the significance of ongoing studies and advancements in AI and its incorporation with new technologies such as quantum computing and blockchain. The strategic use of AI will be essential in adapting to future challenges and taking advantage of new opportunities as the financial services sector evolves. The continuous developments in AI are not only changing financial processes but are also preparing for a more dynamic, inclusive, and resistant financial environment.

REFERENCES

- [1] Kaya, O., Schilbach, J., AG, D. B., & Schneider, S. (2019). Artificial intelligence in banking. *Artificial intelligence*.
- [2] Königstorfer, F., & Thalmann, S. (2020). Applications of Artificial Intelligence in commercial banks—A research agenda for behavioral finance. *Journal of behavioral and experimental finance*, 27, 100352.
- [3] Gigante, G., & Zago, A. (2022). DARQ technologies in the financial sector: artificial intelligence applications in personalized banking. *Qualitative Research in Financial Markets*, 15(1), 29–57.
- [4] Malali, A. B., & Gopalakrishnan, S. (2020). Application of artificial intelligence and its powered technologies in the Indian banking and financial industry: An overview. *IOSR Journal Of Humanities And Social Science*, 25(4), 55–60.
- [5] Bahrammirzaee, A. (2010). A comparative survey of artificial intelligence applications in finance: artificial neural networks, expert system and hybrid intelligent systems. *Neural Computing and Applications*, 19(8), 1165–1195.
- [6] Yu, T. R., & Song, X. (2021). Big data and artificial intelligence in the banking industry. In *Handbook of financial econometrics, mathematics, statistics, and machine learning* (pp. 4025–4041).
- [7] Milojević, N., & Redzepagic, S. (2021). Prospects of artificial intelligence and machine learning application in banking risk management. *Journal of Central Banking Theory and Practice*, 10(3), 41–57.
- [8] Ashta, A., & Herrmann, H. (2021). Artificial intelligence and fintech: An overview of opportunities and risks for banking, investments, and microfinance. *Strategic Change*, 30(3), 211–222.
- [9] Pau, L. F., Gianotti, C., Pau, L. F., & Gianotti, C. (1990). Applications of artificial intelligence in banking, financial services and economics (pp. 22–46). Springer Berlin Heidelberg.



- [10] Kochhar, K., Purohit, H., & Chutani, R. (2019). The rise of artificial intelligence in the banking sector. In *The 5th International Conference on Educational Research and Practice (ICERP)* (Vol. 127).
- [11] Chan, C., Chow, C., Wong, J., Dimakis, N., Nayler, D., Bermudes, J., ... & Baker, M. (2019). Artificial intelligence applications in financial services. *Asset management and insurance*.
- [12] Oliver, W., & Marsh, H. (2019). Artificial intelligence applications in financial services.
- [13] Aithal, P. S. (2023). An Analytical Study of Applications of Artificial Intelligence on Banking Practices. *International Journal of Management, Technology and Social Sciences (IJMTS)*, 8(2), 133-144.
- [14] Rahman, M., Ming, T. H., Baigh, T. A., & Sarker, M. (2023). Adoption of artificial intelligence in banking services: an empirical analysis. *International Journal of Emerging Markets*, 18(10), 4270-4300.
- [15] Huang, J., Chai, J., & Cho, S. (2020). Deep learning in finance and banking: A literature review and classification. *Frontiers of Business Research in China*, 14(1), 13.
- [16] Mahalakshmi, V., Kulkarni, N., Kumar, K. P., Kumar, K. S., Sree, D. N., & Durga, S. (2022). The role of implementing artificial intelligence and machine learning technologies in the financial services industry for creating competitive intelligence. *Materials Today: Proceedings*, 56, 2252-2255.
- [17] Kotios, D., Makridis, G., Fatouros, G., & Kyriazis, D. (2022). Deep learning enhancing banking services: a hybrid transaction classification and cash flow prediction approach. *Journal of big Data*, 9(1), 100.
- [18] Adamu, J. A. (2019). Advanced stochastic optimization algorithm for deep learning artificial neural networks in banking and finance industries. *Risk and Financial Management*, 1(1), p8-p8.
- [19] Hassani, H., Huang, X., Silva, E., & Ghodsi, M. (2020). Deep learning and implementations in banking. *Annals of Data Science*, 7, 433-446.
- [20] Janiesch, C., Zschech, P., & Heinrich, K. (2021). Machine learning and deep learning. *Electronic Markets*, 31(3), 685-695.
- [21] Culkin, R., & Das, S. R. (2017). Machine learning in finance: the case of deep learning for option pricing. *Journal of Investment Management*, 15(4), 92-100.
- [22] Biju, A. K. V. N., Thomas, A. S., & Thasneem, J. (2024). Examining the research taxonomy of artificial intelligence, deep learning & machine learning in the financial sphere—a bibliometric analysis. *Quality & Quantity*, 58(1), 849-878.
- [23] Donepudi, P. K. (2019). Automation and machine learning in transforming the financial industry. *Asian Business Review*, 9(3), 129-138.
- [24] Pothumsetty, R. (2020). Implementation of Artificial Intelligence and Machine learning in Financial services. *International Research Journal of Engineering and Technology*, 7(03).
- [25] George, A. S., & George, A. H. (2023). A review of ChatGPT AI's impact on several business sectors. *Partners Universal International Innovation Journal*, 1(1), 9-23.
- [26] Huang, K., Chen, X., Yang, Y., Ponnappalli, J., & Huang, G. (2023). ChatGPT in Finance and Banking. In *Beyond AI: ChatGPT, Web3, and the Business Landscape of Tomorrow* (pp. 187-218). Cham: Springer Nature Switzerland.
- [27] Roy, D., & Lohar, P. (2023). Banking in the Age of ChatGPT: Shape of Things to Come in India. *Vinimaya*, 44(1), 18-24.
- [28] Rane, N. (2023). Role and Challenges of ChatGPT and Similar Generative Artificial Intelligence in Finance and Accounting. Available at SSRN 4603206.
- [29] Rane, N., Choudhary, S., & Rane, J. (2024). Gemini or ChatGPT? Efficiency, Performance, and Adaptability of Cutting-Edge Generative Artificial Intelligence (AI) in Finance and Accounting. *Efficiency, Performance, and Adaptability of Cutting-Edge Generative Artificial Intelligence (AI) in Finance and Accounting* (February 19, 2024).
- [30] Khan, M. S., & Umer, H. (2024). ChatGPT in finance: Applications, challenges, and solutions. *Heliyon*, 10(2).
- [31] Paramesha, M., Rane, N., & Rane, J. (2024). Enhancing Resilience through Generative Artificial Intelligence such as ChatGPT. Available at SSRN 4832533.
- [32] Rane, N., Paramesha, M., Choudhary, S., & Rane, J. (2024). Artificial Intelligence, Machine Learning, and Deep Learning for Advanced Business Strategies: a Review. *Machine Learning, and Deep Learning for Advanced Business Strategies: a Review* (May 21, 2024).
- [33] Villar, A. S., & Khan, N. (2021). Robotic process automation in banking industry: a case study on Deutsche Bank. *Journal of Banking and Financial Technology*, 5(1), 71-86.
- [34] Madakam, S., Holmukhe, R. M., & Jaiswal, D. K. (2019). The future digital work force: robotic process automation (RPA). *JISTEM–Journal of Information Systems and Technology Management*, 16, e201916001.
- [35] Asatiani, A., & Penttinen, E. (2016). Turning robotic process automation into commercial success—Case OpusCapita. *Journal of Information Technology Teaching Cases*, 6, 67-74.



- [36] Kedziora, D., & KIVIRANTA, H. (2018). Digital Business Value Creation with Robotic Process Automation (rpa) in Northern and Central Europe. *Management* (18544223), 13(2)
- [37] Thekkethil, M. S., Shukla, V. K., Beena, F., & Chopra, A. (2021, September). Robotic process automation in banking and finance sector for loan processing and fraud detection. In 2021 9th international conference on reliability, infocom technologies and optimization (trends and future directions)(ICRITO) (pp. 1-6). IEEE.
- [38] Jędrzejka, D. (2019). Robotic process automation and its impact on accounting. *Zeszyty Teoretyczne Rachunkowości*, (105), 137-166.
- [39] Van Chuong, L., Hung, P. D., & Diep, V. T. (2019, July). Robotic process automation and opportunities for Vietnamese market. In Proceedings of the 7th International Conference on Computer and Communications Management (pp. 86-90).
- [40] Hosen, M., Thaker, H. M. T., Subramaniam, V., Eaw, H. C., & Cham, T. H. (2022, September). Artificial intelligence (AI), blockchain, and cryptocurrency in finance: current scenario and future direction. In *International Conference on Emerging Technologies and Intelligent Systems* (pp. 322-332). Cham: Springer International Publishing.
- [41] Odeyemi, O., Okoye, C. C., Ofodile, O. C., Adeoye, O. B., Addy, W. A., & Ajayi-Nifise, A. O. (2024). Integrating AI with blockchain for enhanced financial services security. *Finance & Accounting Research Journal*, 6(3), 271-287.
- [42] Dewasiri, N. J., Karunaratne, K. S. S. N., Menon, S., Jayarathne, P. G. S. A., & Rathnasiri, M. S. H. (2023). Fusion of Artificial Intelligence and Blockchain in the Banking Industry: Current Application, Adoption, and Future Challenges. In *Transformation for Sustainable Business and Management Practices: Exploring the Spectrum of Industry 5.0* (pp. 293-307). Emerald Publishing Limited.
- [43] Addula, S. R., Meduri, K., Nadella, G. S., & Gonaygunta, H. AI, and Blockchain in Finance: Opportunities and Challenges for the Banking Sector.
- [44] Ravi, H. (2021). Innovation in banking: fusion of artificial intelligence and blockchain. *Asia Pacific Journal of Innovation and Entrepreneurship*, 15(1), 51-61.
- [45] An, Y. J., Choi, P. M. S., & Huang, S. H. (2021). Blockchain, cryptocurrency, and artificial intelligence in finance. In *Fintech with artificial intelligence, big data, and blockchain* (pp. 1-34). Singapore: Springer Singapore.
- [46] Kumar, S., Lim, W. M., Sivarajah, U., & Kaur, J. (2023). Artificial intelligence and blockchain integration in business: trends from a bibliometric-content analysis. *Information Systems Frontiers*, 25(2), 871-896.
- [47] Nuhiu, A., & Aliu, F. (2023). The Benefits of Combining AI and Blockchain in Enhancing Decision-Making in Banking Industry. In *Integrating Blockchain and Artificial Intelligence for Industry 4.0 Innovations* (pp. 305-326). Cham: Springer International Publishing.
- [48] Egger, D. J., Gambella, C., Marecek, J., McFaddin, S., Mevisen, M., Raymond, R., ... & Yndurain, E. (2020). Quantum computing for finance: State-of-the-art and future prospects. *IEEE Transactions on Quantum Engineering*, 1, 1-24.
- [49] Orús, R., Mugel, S., & Lizaso, E. (2019). Quantum computing for finance: Overview and prospects. *Reviews in Physics*, 4, 100028.
- [50] Bova, F., Goldfarb, A., & Melko, R. G. (2021). Commercial applications of quantum computing. *EPJ quantum technology*, 8(1), 2.
- [51] Ganapathy, A. (2021). Quantum computing in high frequency trading and fraud detection. *Engineering International*, 9(2), 61-72.
- [52] Deodoro, J., Gorbanyov, M., Malaika, M., & Sedik, T. S. (2021). Quantum computing and the financial system: spooky action at a distance?. *International Monetary Fund*.
- [53] Mosteanu, N. R., & Faccia, A. (2021). Fintech frontiers in quantum computing, fractals, and blockchain distributed ledger: Paradigm shifts and open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 7(1), 19.
- [54] Krishnakumar, A. (2020). Quantum Computing and Blockchain in Business: Exploring the applications, challenges, and collision of quantum computing and blockchain. Packt Publishing Ltd.
- [55] Albareti, F. D., Ankenbrand, T., Bieri, D., Hänggi, E., Lötscher, D., Stettler, S., & Schöngens, M. (2022). A structured survey of quantum computing for the financial industry. arXiv preprint arXiv:2204.10026.
- [56] Sotelo, R., Corbelleto, D., Dri, E., Giusto, E., & Montrucchio, B. (2024). Quantum Computing in Finance: the Intesa Sanpaolo Experience. *IEEE Engineering Management Review*.

DECLARATIONS

- Funding: No funding was received.



- Conflicts of interest/Competing interests: No conflict of interest.
- Availability of data and material: Not applicable.
- Code availability: Not applicable.
- Acknowledgments: Not Applicable.