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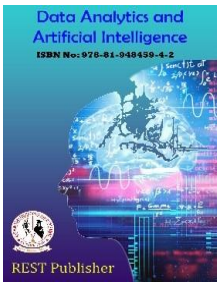

Evaluating Artificial Intelligence in Banking: A Complex Proportionality Assessment (COPRAS) Approach

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Abstract: *Artificial Intelligence (AI) is revolutionizing the banking industry by enhancing operational efficiency, personalizing customer experiences, and improving decision-making processes. AI technologies, such as machine learning, natural language processing, and predictive analytics, are being leveraged to streamline operations, detect fraudulent activities, and provide tailored financial advice. Banks are using AI-driven algorithms to analyze vast amounts of data in real-time, enabling them to offer personalized financial products and services, optimize risk management, and automate routine tasks. AI Chabot's and virtual assistants are transforming customer service by providing instant support and addressing queries around the clock. Additionally, AI helps in credit scoring and loan approvals by assessing a broader range of variables, leading to more accurate and equitable decisions. Overall, AI is driving innovation in banking, offering enhanced security, efficiency, and customer satisfaction. Research Significance: The significance of Artificial Intelligence (AI) in banking lies in its transformative impact on efficiency, security, and customer engagement. AI technologies enable banks to process vast amounts of data swiftly, improving decision-making and operational efficiency. They enhance fraud detection and risk management through advanced predictive analytics and anomaly detection. AI-driven personalization offers tailored financial solutions, improving customer satisfaction and loyalty. Furthermore, AI automation reduces operational costs and minimizes human error. As the banking industry faces increasing competition and evolving regulatory demands, AI provides a crucial competitive edge, driving innovation and adapting to dynamic market conditions. Methodology: The Complex Proportionality Assessment (COPRAS) method is a multi-criteria decision-making method that ranks options according to several conflicting criteria It assesses the proportionality of each alternative concerning the desired outcomes. The method involves normalizing criteria values, calculating weighted scores for each alternative, and then determining the overall performance by comparing these scores. COPRAS provides a systematic approach to decision-making, allowing for a comprehensive evaluation of alternatives by considering their relative advantages and disadvantages across various criteria. This method is particularly useful in complex decision environments where multiple factors need to be balanced. Alternative: Chabot's for Customer Service, Fraud Detection Systems, Automated Loan Approval, Personalized Financial Advising, Credit Scoring Models, Anti-Money Laundering (AML) Systems, Robotic Process Automation (RPA) for Back-office Tasks, AI-driven Investment Management. Evaluation Parameters: Cost Reduction, Efficiency Improvement, Customer Satisfaction, Accuracy, Scalability. Result: According to the results, Credit Scoring Models has the lowest score, while Personalized Financial Advising has the highest rank.*

Keywords: *Artificial Intelligence (AI), Banking, Natural Language Processing (NLP), COPRAS Method.*

1. INTRODUCTION

With the rise of internet banking and self-service branch networks, the banking sector has emerged as a major user of artificial intelligence (AI) technology. AI technologies are being used to automatically reply to consumer inquiries, track spending and savings trends, and carry out other duties on their behalf. Examples of these tools are Natural Language Processing (NLP) and Machine Learning. Employees can concentrate on higher-value work and cut expenses by automating repetitive operations that are prone to human mistake. Additionally, banks are using AI-driven analytics and big data to deliver prompt, individualized client care. AI not only improves customer service but also gives banks more insight into the interests and behaviors of their customers, which

helps them better customize their goods and services. [1] Technological advancements are rapidly shaping the world, with artificial intelligence (AI) emerging as one of the fastest-growing technologies globally. Various industries, including the banking sector, are integrating AI into their operations. AI is anticipated to be a key component of banking by utilizing complex data analytics to combat fraud and enhance regulatory compliance. While AI is not a replacement for human workers, it significantly enhances efficiency and speeds up complex calculations that would be challenging to perform manually. In the banking industry, AI is driving revenue growth by improving risk management and customer satisfaction. As the sector becomes increasingly competitive and innovation accelerates, the adoption of AI has become a crucial part of strategic planning. This thesis explores the application of AI in banking, its role in improving business decisions, the implementation of AI in business and its effects on Indian banks. The research methodology includes both primary and secondary data, with the researcher conducting interviews with 50 banking professionals to assess the effects of artificial intelligence on Indian banks. [2] Recent years have seen a significant increase in academic interest in artificial intelligence (AI), which is now closer to commercial application because to breakthroughs in technology and faster data availability. Major internet corporations like Google, YouTube, Amazon, and Facebook have made large investments in it, demonstrating its importance to global business strategies. AI has been implemented in pilot programs in the banking industry, where data is extremely valuable, but full-scale implementations have not yet been realized. This study examines the factors driving and hindering the successful implementation of AI in banking, utilizing panel data from 28 expert interviews with AI that were semi-structured in the finance sector. It highlights the necessity of trained algorithms for AI-driven prototypes and processes, noting that full AI deployment will require these systems to function independently of human intervention and address ethical concerns. [3] Artificial intelligence (AI) is increasingly becoming a key part of daily life, particularly in the banking sector. To remain competitive, it is essential for banks to adopt AI. According to McKinsey, AI solutions are projected to add up to $1 trillion annually to the global banking industry (Biswas & Carson, 2020). AI technologies enable greater service personalization for both customers and employees, which in turn boosts revenue. Additionally, automating internal processes enhances efficiency, reduces operational costs, and minimizes system errors by optimizing resource utilization. AI also presents new opportunities for improving banking processes through valuable insights. AI integration, focusing on improving customer engagement and increasing sales. The study focuses on Indian banks in metropolitan areas, where tech-savvy customers lead fast-paced lives, prefer personalized services, and expect seamless, error-free experiences. Data collection focuses on both back-office operations and customer-facing front-office experiences. Within banks, back-office operations often involve repetitive and clerical tasks that are time-consuming and complex. These processes often run on outdated legacy systems, requiring multiple employees to handle a single customer request. Manual processes like these are costly and prone to errors. To address issues related to time, cost, and errors, it's essential to modernize these processes with the latest technological advancements. [4] The Machine Learning (ML) and Artificial Intelligence (AI) in finance have seen significant growth recently, with organizations leveraging these technologies to enhance both front-end and back-end business processes. These innovations have improved efficiency and the customer experience. Computational intelligence has become a crucial tool for gaining a competitive advantage by optimizing decision-making processes. The banking industry, in particular, is experiencing a transformation driven by ML and AI, which are poised to revolutionize it. This article will explore how various banking functions are utilizing computational intelligence to improve operations. While many financial institutions face challenges in fully adopting these technologies, their influence is rapidly spreading throughout the industry. [5] The financial sector, along with other industries, is experiencing significant transformations due to modern technologies. Blockchain, biometrics, virtual and augmented reality (VR/AR), big data, business analytics, and artificial intelligence (AI) are some of the major forces behind this digital revolution. These technologies are reshaping the organizational landscape, especially in banking. The banking industry, in particular, faces heightened competition due to the rise of digital technologies. Traditional banks now contend with non-banking competitors, such as Neobanks, which offer services like account management, lending, and borrowing entirely through online platforms (e.g., Tinkoff Bank, Talk Bank). Moreover, tech giants like Google, Apple, Facebook, Amazon (GAFA), along with Chinese companies like Alibaba and Baidu, are entering the financial sector, providing a seamless customer experience and aiming to maintain long-term engagement. To remain competitive, traditional banks are embracing digital transformation. They are adopting new financial technologies to better serve customers in a rapidly evolving environment. Banks are focusing on personalization, offering 24/7 customer support, and enhancing the customer journey throughout their life cycle. They are also developing financial ecosystems through digital platforms that provide diverse services, from online payments and marketplaces to lifestyle and education solutions. Digital technologies are fundamentally altering the way banks interact with customers, financial intermediaries, and regulators, shifting service delivery towards digital channels. While traditional banking solutions will persist, their prevalence will diminish over time as digital services continue to expand. [6] With the use of artificial intelligence (AI), machines can mimic human tasks, adapt to new inputs, and learn from human experiences. AI is evolving quickly, transforming industries by automating processes, enhancing cognitive tasks, and enabling intelligent

data analysis. However, a key challenge for users is comprehending and trusting the outcomes generated by AI algorithms. To tackle this issue, this paper examines recent advancements in explainable artificial intelligence (XAI) methods and tools. It proposes a new XAI framework that supports the development of interpretable models while preserving strong learning performance. The paper introduces an interactive, evidence-based approach to help users better understand and trust AI-generated outputs. Using a case study from the banking sector, the authors explore customer transaction analysis, presenting a digital dashboard to facilitate user interaction with algorithmic results. They also discuss how this XAI method can boost data scientists' confidence in interpreting AI outcomes. [7]Digital transformation is recognized as a major driving force behind companies' efforts to rapidly evolve their business models and deliver substantial value to customers in highly competitive, fast-paced environments. Utilizing artificial intelligence (AI), gained widespread acceptance as one of the key enablers of digital transformation across various industries. By fostering collaboration with innovative initiatives, AI provides the flexibility and versatility required in today's demanding business landscape. A major use of AI is its ability to enhance overall efficiency and productivity. Organizations across sectors are increasingly embracing digital transformation. In particular, the Indian banking industry has significantly adopted advanced technologies to serve modern customers and expand their financial services while ensuring the delivery of high-quality offerings. AI is essential for simplifying banking procedures and operations in Indian banks, ranging from accounting and sales to contracts and cybersecurity. [8]Artificial intelligence (AI) has emerged as a key element in the evolving landscape of banking, playing a crucial role in driving innovation. This study focuses on examining consumers' perspectives on adopting AI in the banking industry in five Asian nations: China, Pakistan, Thailand, Saudi Arabia, and Iran. Data were collected from 799 respondents using a questionnaire. According to the research, customers' intentions to utilize AI in banking are favorably influenced by elements like awareness, attitude, subjective norms, perceived utility, and knowledge of the technology. On the other hand, perceived risk has a negative, though significant, impact on this intention. These insights are valuable for banks looking to develop strategies that build customer confidence, reduce perceived risks, and enhance trust in digital banking technologies. By harnessing AI technologies, the banking industry aims to improve customer service and drive overall growth and profitability. [9]Banking is a highly data-driven industry, relying on analyzing enormous volumes of data to apply AI to extract insightful knowledge and useful business patterns. With advancements in technology, customers now prioritize simplicity and convenience, expecting quick and efficient service without the need to wait in queues or spend long hours online for query resolution. Processes like purchasing insurance or navigating complex, time-consuming credit assessments are being streamlined using big data. By leveraging these insights, banks can enhance customer satisfaction and improve their operational efficiency. [10]In the upcoming years, artificial intelligence will have a big impact on the financial sector. Banks are using it more and more to manage a variety of data and assess and process loan applications. This reduces the possibility of fraud and makes it possible to automate client operations and resource-intensive, repetitive processes. all while maintaining high-quality standards. The most promising AI applications are expected to enhance the strength and efficiency of the banking sector. Specifically, we examine AI applications in Intelligent document processing, credit management, and fraud detection and prevention. Advanced fraud detection algorithms and prevention systems are in high demand as digital transactions become more commonplace. banking. Traditional methods for detecting bank fraud may no longer be adequate due to the complexity of fraudulent activities. AI algorithms, in contrast, offer more effective solutions. Credit management is both time-consuming and resource-intensive, requiring significant effort due to the numerous steps involved. Banks can leverage advanced AI/ML models to Determine loan amounts, arrange prices, and evaluate potential clients for lending services., thereby reducing fraud risk through real-time analysis of large and diverse data sets. Documents play a crucial role in finance, affecting both organizational and daily operations. A large portion of this data is stored in various digital formats such as emails, online forms, PDFs, and scanned images. Extracting and utilizing this extensive data set can be challenging for banks. We discuss how AI techniques can automatically extract important data from all submitted documents, regardless of their format, and integrate this data into the bank's existing systems while ensuring consistency. [11]Artificial Intelligence (AI) has become integral in business, particularly within the Finance Department, where it is aimed at boosting economic development, efficiency, and productivity. Despite this potential, growth might be stalling due to increasing inequalities, challenges in education, population dynamics, credit issues, and environmental pressures. Technological advancements, including AI, are reshaping the business landscape to navigate the volatility, uncertainty, complexity, and ambiguity known as the VUCA world. This transformation spans financial markets—such as equities, bonds, interest rates, foreign exchange, derivatives, and banks and other financial institutions as well as payment processors, insurance firms, mutual funds, and microfinance institutions. AI is revolutionizing strategies in the financial sector, pushing for greater transparency and collaboration. The concept of AI aims to enable machines to perform tasks that typically require human intelligence. AI's roots are often linked to mid-20th century robotics, the imitation game, and foundational theories of digital computers. Key milestones include the creation of the analog computer by a US Marine in 1938 and the digital computer created by Konrad Zuse in 1939. The Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI), led by

Marvin Minsky and John McCarthy at Dartmouth College, is credited with coining the phrase "artificial intelligence" in 1956. [12]Artificial Intelligence (AI) has a long history in India, with research institutions and universities exploring various AI technologies for decades, particularly in the realm of social change. As AI technology becomes more accessible and cost-effective, it is now entering the mainstream, with large enterprises and startups alike recognizing its potential. According to an Accenture report, AI adoption could potentially contribute nearly $1 trillion to the Indian economy by 2035. AI, which enables machines to replicate and enhance human intelligence, is heralding the largest technological revolution ever witnessed. It is increasingly integrated across industries, with significant impacts in sectors like banking, where it simplifies and enhances interactions with machines and systems. By combining the speed and precision of machines with human-like intelligence, AI is poised to revolutionize how financial services firms, including banks and insurance companies, operate, innovate, and improve customer experiences. For example, the nation's biggest bank, State Bank of India (SBI), held a hackathon called "Code for Banking" recently to encourage the creation of solutions that make use of cutting-edge technology like blockchain and artificial intelligence.. SBI already employs the chatbot SIA (SBI Intelligent Assistant), while private banks like HDFC Bank and ICICI Bank have introduced their own chatbots (EVA and iPal, respectively) to enhance customer service. Some banks have even deployed robots in select branches to further improve customer interactions. Canara Bank has installed robots named Mitra and Candy in some of its Bangalore offices, and HDFC Bank has implemented Robo IRA (Interactive Robotic Assistant) in certain branches. [13]The financial industry and the economy as a whole are being progressively shaped by artificial intelligence (AI) and machine learning (ML). The impact of AI and ML on bank risk management is the main topic of this article, particularly in light of the recent global financial crisis. The study investigates how AI and ML could improve bank risk management, addressing both the opportunities and challenges involved. The study emphasizes how AI and ML can help tackle contemporary financial and economic problems, such as those brought on by the Covid-19 pandemic. While the primary focus is on credit risk management, the paper also examines AI and ML applications in other areas of risk management. It concludes that well-planned and effectively implemented AI, Credit, market, liquidity, and operational risks are just a few of the risk management categories where ML, deep learning, and big data analytics can have a major positive influence. [14]One area that shows increasing promise is the incorporation of artificial intelligence (AI) technologies into corporate processes. AI not only makes corporate processes more efficient, but it also lowers the associated costs for organizations. Additionally, AI minimizes the need for human resources in routine tasks. This study aims to create a collection of metrics to evaluate the efficiency of AI technologies in large companies, using Crédit Agricole, a leading foreign-invested bank in Ukraine, as a case study. Statistical and economic analysis methods are employed to compare performance indicators with and without AI. Key quantitative metrics include client application processing time, customer service costs, the number of claims handled by bank staff, and the savings from streamlined business processes. The study's findings highlight the practical advantages of AI in reducing work time and financial expenditures, demonstrating increased labor productivity at the bank branch due to AI-driven process automation. This research opens avenues for further exploration into how AI impacts financial performance and market capitalization. [15-16]

2. MATERIALS & METHODS

Alternative: Chatbots for Customer Service, Fraud Detection Systems, Automated Loan Approval, Personalized Financial Advising, Credit Scoring Models, Anti-Money Laundering (AML) Systems, Robotic Process Automation (RPA) for Back-office Tasks, AI-driven Investment Management.

Chatbots for Customer Service: Chatbots, which offer real-time, round-the-clock assistance, have completely transformed customer service. These artificial intelligence (AI) technologies may do a variety of jobs, such as processing transactions, addressing problems, and providing answers to frequently asked questions. Their conversational operation is facilitated by natural language processing (NLP), which allows them to comprehend and react to user input. Enhanced customer experience, financial savings, and increased efficiency are the main advantages of chatbots. Businesses can devote human resources to more intricate and nuanced jobs by automating regular interactions, guaranteeing that consumers receive accurate and timely support.

Fraud Detection Systems: Fraud detection systems leverage AI and machine learning to identify and prevent fraudulent activities. Large volumes of data are analyzed by these systems in order to find trends and abnormalities that might point to fraud. For example, AI algorithms in the finance sector can track transactions in real-time, flagging unusual patterns such as large transactions from unfamiliar locations or rapid changes in account behavior. By continuously learning and adapting These systems gradually increase their accuracy in response to novel fraud techniques. reducing false positives and enhancing the overall security of financial transactions.

Automated Loan Approval: Automated loan approval systems use AI to streamline and expedite the loan application process. Traditional loan approval involves a lengthy review process where human underwriters assess applications based on credit scores, financial history, and other factors. Automated systems, however, use machine learning algorithms to evaluate these factors more quickly and consistently. They can analyze applicant data, predict creditworthiness, and make approval decisions just a fraction of the time that a human would require. This expedites the procedure and lessens biases and mistakes leading to more equitable lending practices.

Personalized Financial Advising: Personalized financial advising uses AI to Depending on the unique client profiles, provide individualized financial advice and goals. AI algorithms analyze a client's financial situation, investment history, risk tolerance, and future goals to generate customized recommendations. This could involve portfolio management, retirement planning, or tax optimization strategies. Unlike traditional advisors, AI-driven systems can swiftly process and evaluate enormous volumes of data, offering guidance and insights that are highly personalized and adaptable to changing market conditions. This personalization helps clients make more informed decisions and achieve their financial objectives.

Credit Scoring Models: Credit scoring models assess an individual's creditworthiness using statistical methods and data analysis. Conventional credit scoring mainly considers financial behaviors including debt levels and payment histories, as well as credit history. However, more data is now included in modern credit scoring models, such as transactional data and information from social media and other alternative data sources. These models are improved by artificial intelligence (AI) and machine learning, which may spot intricate correlations and patterns that conventional approaches might miss. As a result, credit evaluations are more thorough and precise, which may increase credit availability for people who would not have been considered by traditional scoring methods.

Anti-Money Laundering (AML) Systems: Anti-money laundering systems use artificial intelligence to identify and stop money laundering. Money laundering is the process of hiding the source of funds that were obtained unlawfully in order to make them appear genuine. Advanced algorithms are utilized by AML systems to keep an eye on financial activities and spot suspect trends, like large or unusual transactions, frequent transfers, and transactions involving countries that pose a high risk. By continuously analyzing transaction data and applying risk-based models, these systems help financial institutions comply with regulatory requirements and mitigate the risks associated with money laundering.

Robotic Process Automation (RPA) for Back-office Tasks: Software robots are used in robotic process automation (RPA) to automate rule-based and repetitive tasks in back office operations. These tasks can include data entry, invoice processing, and account reconciliation. RPA tools mimic human interactions with software applications, executing tasks with high accuracy and efficiency. Organizations can save operating expenses, cut down on errors, and free up human workers to work on more strategically oriented and high-value tasks by automating repetitive procedures. RPA can significantly enhance productivity and streamline business operations across various sectors.

AI-driven Investment Management: AI-driven investment management, or robo-advisory, uses artificial intelligence to manage investment portfolios. These programs examine economic statistics, market data, and investor characteristics to make investment decisions and optimize portfolios. Unlike traditional investment managers, AI-driven platforms can process vast amounts of data in real-time, providing timely and data-driven investment strategies. They can also personalize investment approaches depending on your financial objectives and risk tolerance. This technology democratizes access to sophisticated investment strategies, facilitating people's ability to benefit from professional-grade portfolio management.

Evaluation Parameters: Cost Reduction, Efficiency Improvement, Customer Satisfaction, Accuracy, Scalability

Cost Reduction: Cost reduction is a primary goal for many technology implementations. By automating tasks, reducing manual effort, or optimizing processes, organizations can achieve significant savings. For instance, robotic process automation (RPA) can drastically cut costs associated with manual data entry and repetitive tasks by replacing human labor with software robots. Similarly, AI-driven fraud detection systems can reduce losses from fraudulent transactions, ultimately saving money on fraud-related expenses.

Cost reduction is evaluated by comparing the costs of implementing and maintaining the technology against the savings generated. This includes initial investment costs, ongoing operational costs, and potential cost savings

from improved efficiency or reduced errors. A successful technology implementation should demonstrate a clear return on investment (ROI) by lowering overall operational costs while maintaining or improving service quality.

Efficiency Improvement: Efficiency improvement measures how effectively technology enhances operational processes. It focuses on how well technology streamlines workflows, reduces time spent on tasks, and eliminates bottlenecks. For example, automated loan approval systems speed up the decision-making process compared to traditional manual reviews, enabling faster response times and freeing up human resources for more complex tasks.

Efficiency improvement is assessed by analyzing process metrics before and after technology implementation. Key indicators might include task completion times, processing speeds, and the volume of work handled. Improved efficiency should lead to quicker turnaround times, higher productivity, and better resource allocation, which ultimately contribute to the overall success of the technology solution.

Customer Satisfaction: Customer satisfaction evaluates how well technology meets the needs and expectations of customers. Technologies like chatbots and AI-driven personalized financial advising directly impact customer experience by providing timely, relevant, and accurate responses to customer queries. High customer satisfaction often results in enhanced brand reputation, favorable evaluations, and a rise in consumer loyalty.

Measuring customer satisfaction involves gathering feedback through surveys, reviews, and direct interactions. Customer retention rates, net promoter scores (NPS), and customer satisfaction scores are important indicators. An effective technology solution should enhance the customer experience by offering more convenient, responsive, and personalized service.

Accuracy: Accuracy measures how precisely technology performs its intended functions. Accuracy is vital in the context of AI and machine learning. for tasks such as fraud detection, credit scoring, and investment management. For example, an AI-driven credit scoring model needs to accurately assess creditworthiness to ensure fair and reliable lending decisions. Similarly, anti-money laundering systems must accurately identify suspicious activities to prevent illegal transactions.

Accuracy is evaluated through performance metrics such as error rates, false positives, and true positives. High accuracy indicates that the technology is performing as expected and delivering reliable results. Inaccurate systems, on the other hand, can lead to costly mistakes, compliance issues, and loss of trust.

Scalability: Scalability assesses how well technology can handle increasing volumes of work or adapt to growing demands. A scalable solution can expand its capacity to accommodate more users, transactions, or data without compromising performance. For instance, AI-driven investment management platforms should be able to scale their services to manage larger portfolios as their client base grows.

Scalability is evaluated by testing the technology under various loads and monitoring its performance as demand increases. Key indicators include system performance metrics, response times, and the ability to integrate with other systems. A scalable technology solution should be able to handle growth efficiently, ensuring that performance remains stable as the organization's needs evolve.

3. COMPLEX PROPORTIONALITY ASSESSMENT (COPRAS)

The Complex Proportionality Assessment (COPRAS) method is an advanced approach in multi-criteria decision-making (MCDM), developed by Croatian researcher P. Šijačić in 2001. It is designed to assist decision-makers in evaluating and ranking various alternatives based on multiple criteria, particularly when both positive and negative aspects need to be considered. This versatility makes COPRAS a valuable tool for complex decision environments. [17-19]Foundations and Conceptual Framework COPRAS is based on the principle of proportionality, which assesses how well each alternative meets the criteria in relation to others. Unlike some MCDM methods that might simplify criteria or focus solely on positive aspects, COPRAS provides a nuanced evaluation by addressing both the strengths and weaknesses of each alternative. This balanced approach is particularly useful for criteria that have both beneficial and detrimental effects, offering a more comprehensive evaluation.[20-22]Criteria Identification and Weighting: The first step involves identifying relevant criteria for evaluating alternatives, which can include cost, performance, environmental impact, and social implications. Each criterion is assigned a weight reflecting its importance in the decision-making process. Weights are usually determined through expert judgment, stakeholder input, or analytical methods, helping to prioritize criteria based on their significance.[23]Normalization: Since criteria often differ in units and scales, normalization is necessary to standardize them. This process converts the performance values of each alternative on each criterion into a common range, usually between 0 and 1. Normalization ensures fair comparison across criteria by eliminating biases due to different measurement scales. Techniques such as linear scaling or using maximum and minimum

values can be applied.[24]Calculation of Relative Performance: After normalization, the relative performance of each alternative is calculated. This step determines how well each alternative performs compared to the best-performing option for each criterion. The relative performance scores indicate how close or far an alternative is from the ideal outcome, highlighting its strengths and weaknesses. [25]Evaluation of Proportionality: The core of COPRAS is the evaluation of proportionality, which involves computing a proportional performance score for each alternative. This score combines the performance across all criteria, considering both positive and negative deviations from the ideal. Positive deviations show how well an alternative performs compared to the best possible outcome, while negative deviations reflect any shortcomings.[26]Ranking of Alternatives: Based on the proportional performance scores, alternatives are ranked. Higher scores indicate better overall performance across the criteria. This ranking helps decision-makers identify the most favorable options and make informed choices based on a holistic assessment.[27]Advantages of the COPRAS Method COPRAS is advantageous for its ability to incorporate both positive and negative aspects of alternatives, providing a balanced evaluation. It also accommodates subjective decision-making by allowing the assignment of weights to criteria, which can be adjusted according to stakeholder preferences or expert opinions. The method's flexibility makes it applicable across various fields, such as engineering (for design options), environmental management (for project prioritization), and finance (for investment evaluation).[28]Limitations and Considerations Despite its benefits, COPRAS has some limitations. One major challenge is the sensitivity of results to the weights assigned to criteria, as small changes can significantly alter rankings. Accurate and consistent weight assignment is crucial to avoid biases. Additionally, COPRAS assumes criterion independence, which may not always hold true in real-world scenarios where criteria can interact. Decision-makers should consider potential interactions between criteria to ensure accurate evaluations.[29]Practical Applications and Examples COPRAS has been effectively applied in various practical contexts. For example, in project management, it can evaluate and select the best project based on criteria like cost, benefit, and risk. In urban planning, it helps assess development options by considering factors such as environmental impact and social benefits. In supply chain management, COPRAS can evaluate suppliers based on quality, cost, and reliability, aiding in informed procurement decisions.[30]

COPRAS equation step:

- The COPRAS (Complex Proportional Assessment) Method contains the Following steps.
- Zavadakas and Kaklauskas (1996)
- The MCDM problem and the weights criterions are expressed in terms of eqn. (1) and eqn. respectively.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

$$w_j = [w_1 \ldots \ w_n], \text{ where } \sum_{j=1}^{n}(w_1 \ \ldots \ \ w_n) = 1$$

- Next, the decision matrix is normalized by using eqn. (18) and the weighted normalized matrix is calculated as per eqn. (19)

$$n_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}$$

$$N_{ij} = w_j * n_{ij}$$

Next, calculate the sum B_i of the benefit criteria values

$$B_i = \sum_{j=1}^{K} N_{ij}$$

Next, Calculate the sum C_i of the cost criteria values,

$$C_i = \sum_{j=k+1}^{m} N_{ij}$$

Calculating the relative significance Q_i of each alternative

$$Q_i = B_i + \frac{\min(c_i) \cdot \sum_{i=1}^{n} C_i}{C_i \cdot \sum_{i=1}^{n} \left(\frac{\min(C_i)}{c_i}\right)}$$

Next, Determine the utility degree for each alternative as

$$UD_i = \frac{Q_i}{\max(Q_i)} * 100\ \%$$

3. RESULT AND DISCUSSION

TABLE 1. Artificial Intelligence in Banking

	Cost Reduction	Efficiency Improvement	Customer Satisfaction	Accuracy	Scalability
Chatbots for Customer Service	8	9	8	7	9
Fraud Detection Systems	7	9	7	9	8
Automated Loan Approval	9	9	6	9	9
Personalized Financial Advising	6	7	9	6	7
Credit Scoring Models	8	9	6	9	9
Anti-Money Laundering (AML) Systems	7	9	6	9	7
Robotic Process Automation (RPA) for Back-office Tasks	9	9	6	7	9
AI-driven Investment Management	6	7	9	8	6

Table 1. Shows various applications of Artificial Intelligence (AI) in the banking sector, focusing on five key areas: cost reduction, efficiency improvement, customer satisfaction, accuracy, and scalability. Chatbots for Customer Service: AI-powered chatbots achieve high efficiency (9) and scalability (9), offering round-the-clock assistance, which helps reduce costs (8). They provide decent customer satisfaction (8) by resolving common queries but are somewhat limited in accuracy (7). Fraud Detection Systems: These systems are vital for identifying suspicious activities, with high scores in efficiency (9), accuracy (9), and scalability (8), and they also contribute to cost reduction (7). However, customer satisfaction (7) may be slightly lower due to occasional false positives. Automated Loan Approval: AI systems streamline the loan approval process, scoring high in cost reduction (9), efficiency (9), and accuracy (9). However, customer satisfaction (6) might be affected by the lack of human interaction. Personalized Financial Advising: AI offers tailored financial advice, improving customer satisfaction (9), but its cost-effectiveness (6) and accuracy (6) are moderate. Credit Scoring Models: These models perform well in terms of cost reduction (8), efficiency (9), accuracy (9), and scalability (9) by quickly assessing creditworthiness. Anti-Money Laundering (AML) Systems: These systems are crucial for detecting and preventing illegal transactions. They show high scores in efficiency (9) and accuracy (9), as they process large amounts of transaction data. However, customer satisfaction (6) may be affected due to delays caused by additional checks. AML systems in India have become vital, especially with the rise of digital banking and fintech platforms like Paytm and PhonePe. Robotic Process Automation (RPA) for Back-office Tasks: RPA excels in cost reduction (9), efficiency (9), and scalability (9), automating repetitive tasks such as data entry and compliance checks. This is particularly beneficial for banks like SBI and ICICI, where RPA can help manage the vast volume of transactions and regulatory reporting, streamlining operations while reducing human errors. AI-driven Investment Management: While this application enhances customer satisfaction (9) through personalized portfolio management, it scores lower in cost reduction (6) and scalability (6). Many Indian banks are adopting AI-driven tools to offer investment advice to retail customers. However, due to the relatively early adoption phase, the scalability of such systems remains a challenge.

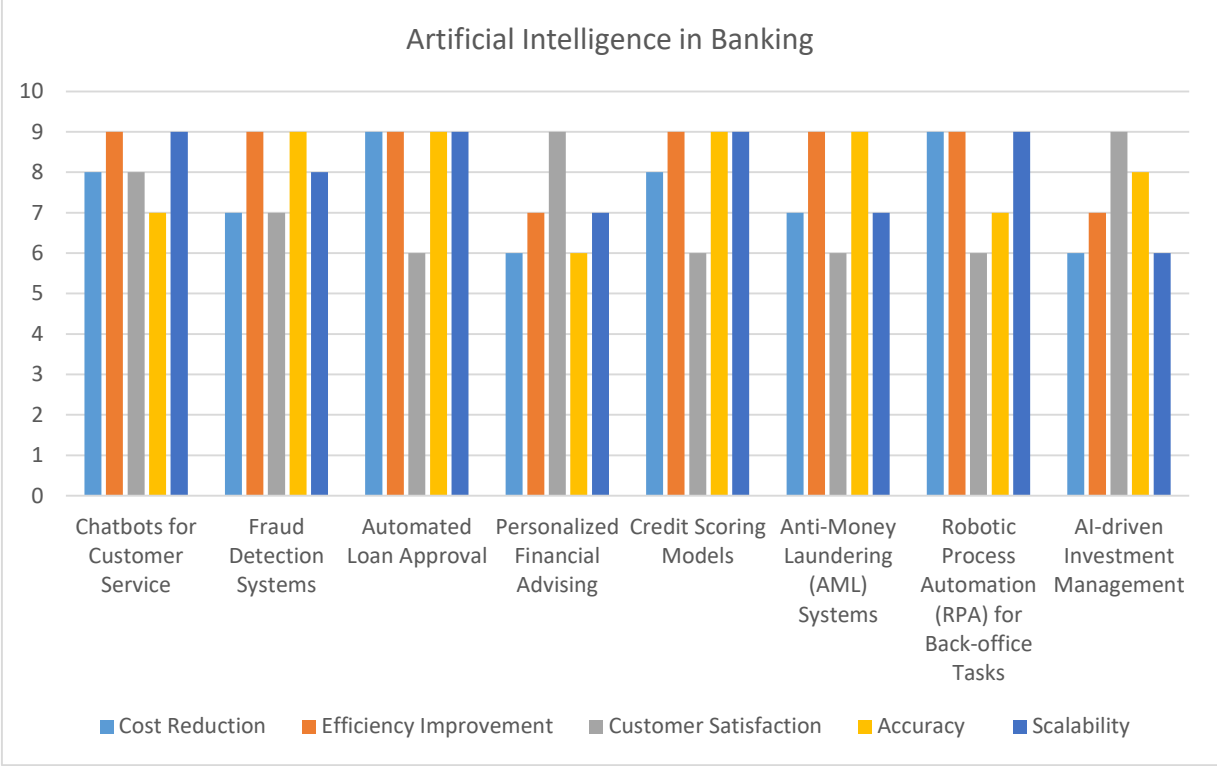

FIGURE 1. Artificial Intelligence in Banking

The figure 1 illustrates the various uses of Artificial Intelligence (AI) in the banking sector and their associated advantages. The horizontal axis displays different AI-driven solutions, while the vertical axis shows the perceived benefits of these solutions. The chart's bars represent the perceived benefits of each AI application across various dimensions. For example, chatbots for customer service are considered to significantly lower costs and increase customer satisfaction. Fraud detection systems are anticipated to boost efficiency and precision, whereas automated loan approval processes are thought to enhance both efficiency and customer satisfaction. Personalized financial advising and credit scoring models are expected to offer customers customized recommendations and accurate evaluations. Anti-money laundering systems are predicted to enhance accuracy and help prevent financial crimes. Robotic process automation (RPA) for back-office tasks is likely to reduce costs and improve efficiency. Lastly, AI-driven investment management is anticipated to improve accuracy and scalability.

TABLE 2. Normalized Data

Normalized Data				
Cost Reduction	**Efficiency Improvement**	**Customer Satisfaction**	**Accuracy**	**Scalability**
0.1333	0.1324	0.1404	0.1094	0.1406
0.1167	0.1324	0.1228	0.1406	0.1250
0.1500	0.1324	0.1053	0.1406	0.1406
0.1000	0.1029	0.1579	0.0938	0.1094
0.1333	0.1324	0.1053	0.1406	0.1406
0.1167	0.1324	0.1053	0.1406	0.1094
0.1500	0.1324	0.1053	0.1094	0.1406
0.1000	0.1029	0.1579	0.1250	0.0938

The table 2 shows normalized data for various AI applications in banking, comparing performance across five key metrics: cost reduction, efficiency improvement, customer satisfaction, accuracy, and scalability. Normalization rescales the original values to a range, usually between 0 and 1, allowing for easier comparison across metrics. For instance, higher normalized values, like 0.1500 for cost reduction, indicate better performance in that area. The data reveals that most AI applications perform well in efficiency improvement

(with values around 0.1324), while customer satisfaction varies more, ranging from 0.1053 to 0.1579. This normalized data helps identify areas where AI excels or requires improvement within the banking sector.

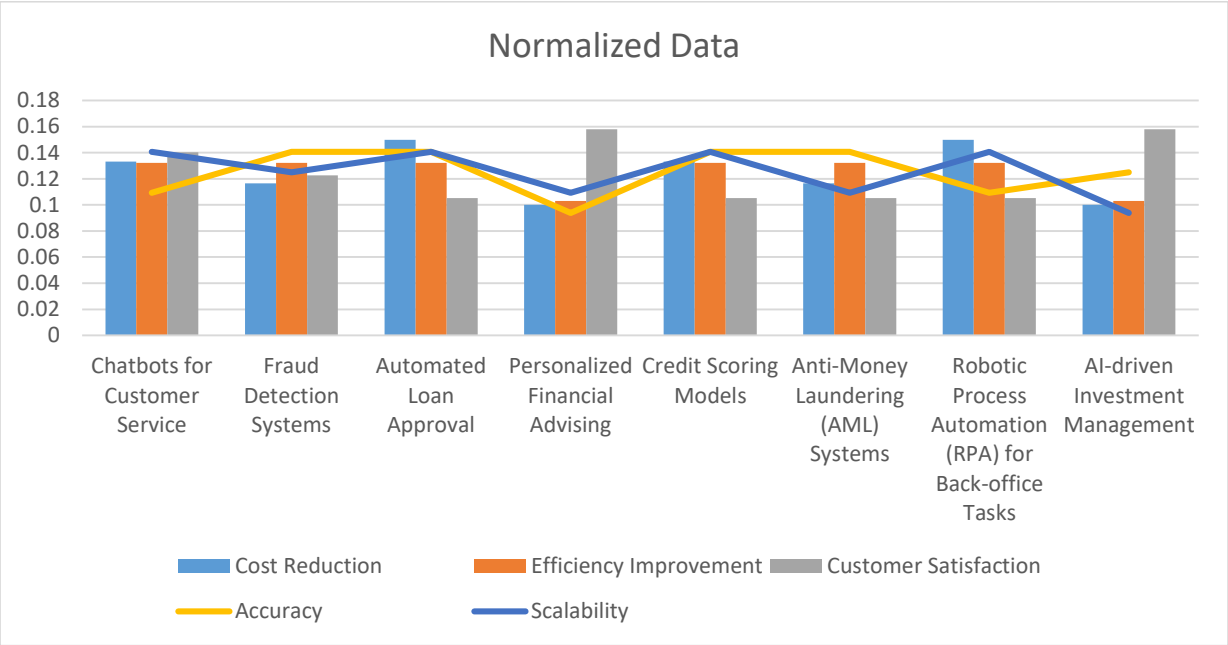

FIGURE 2. Normalized Data

The image displays a normalized data chart that highlights the perceived benefits of various AI applications in the banking sector. The horizontal axis lists different AI solutions, while the vertical axis shows their normalized benefit levels across various dimensions. The chart illustrates how different AI applications contribute to various benefits. For example, chatbots used for customer service are recognized for significantly reducing costs and boosting customer satisfaction, though they have a lesser impact on improving efficiency and accuracy. Conversely, fraud detection systems are expected to enhance efficiency and accuracy but may have a minimal effect on reducing costs or improving customer satisfaction. Automated loan approval processes are anticipated to enhance both efficiency and customer satisfaction. Personalized financial advising and credit scoring models are valued for their ability to provide tailored recommendations and accurate assessments. Anti-money laundering systems are projected to improve accuracy but may not greatly affect cost reduction or customer satisfaction. Robotic process automation (RPA) for back-office functions is seen as beneficial for reducing costs and increasing efficiency, while AI-driven investment management is expected to improve accuracy and scalability. In summary, the chart indicates that AI has the potential to transform the banking industry by boosting efficiency, lowering costs, enhancing customer experiences, and reducing risks. However, the extent of these benefits can vary based on the specific application and its implementation.

TABLE 3. Weight

Weight				
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25

The table 3 shows equal weights of 0.25 assigned to all five metrics—cost reduction, efficiency improvement, customer satisfaction, accuracy, and scalability—across all AI applications in banking. This indicates that each metric is considered equally important when evaluating the performance of AI systems in the sector.

TABLE 4. Weighted normalized decision matrix

Weighted normalized decision matrix				
0.033333	0.033088	0.035088	0.027344	0.035156
0.029167	0.033088	0.030702	0.035156	0.03125
0.0375	0.033088	0.026316	0.035156	0.035156
0.025	0.025735	0.039474	0.023438	0.027344
0.033333	0.033088	0.026316	0.035156	0.035156
0.029167	0.033088	0.026316	0.035156	0.027344
0.0375	0.033088	0.026316	0.027344	0.035156
0.025	0.025735	0.039474	0.03125	0.023438

Table 4 presents a weighted normalized decision matrix for evaluating different AI applications in banking. Each entry in the matrix is calculated by multiplying the normalized values from Table 2 by the weights from Table 3 (which are all 0.25), reflecting the equal importance of each metric: cost reduction, efficiency improvement, customer satisfaction, accuracy, and scalability. Chatbots for Customer Service: Scores are moderate across all metrics, with the highest score in customer satisfaction (0.0351) and scalability (0.0352). This suggests chatbots perform well in satisfying customers and scaling operations. Fraud Detection Systems: These systems show high performance in accuracy (0.0352) but lower scores in cost reduction (0.0292) and scalability (0.0313). They are effective at detecting fraud but less impactful in reducing costs. Automated Loan Approval: It ranks high in cost reduction (0.0375) and efficiency (0.0331), indicating significant benefits in streamlining the loan process, although its customer satisfaction and scalability are moderate. Personalized Financial Advising: This application excels in customer satisfaction (0.0395) but scores lower in cost reduction (0.0250) and accuracy (0.0234), highlighting its strengths in tailoring advice but with higher costs and less precision. Credit Scoring Models: Consistent scores in cost reduction (0.0333) and scalability (0.0352) show their reliability and effectiveness in assessing credit risk and adapting to scale. Anti-Money Laundering (AML) Systems: AML systems exhibit balanced performance with decent scores across all metrics but are particularly strong in accuracy (0.0352). Robotic Process Automation (RPA) for Back-office Tasks: RPA shows high scores in cost reduction (0.0375) and efficiency (0.0331), making it effective for automating back-office processes, though less effective in customer satisfaction. AI-driven Investment Management: This application shows high customer satisfaction (0.0395) but lower scores in other metrics, indicating it is particularly valued for personalized investment advice.

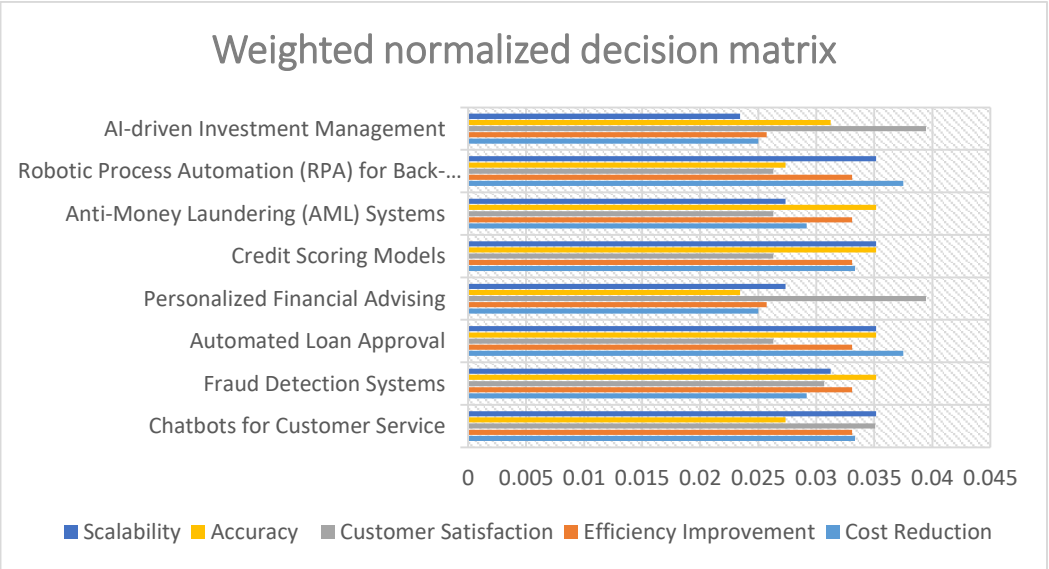

FIGURE 3. Weighted normalized decision matrix

The Weighted Normalized Decision Matrix in the figure 3 offers a detailed assessment of various AI-driven financial technologies across several criteria, including Scalability, Accuracy, Customer Satisfaction, Efficiency Improvement, and Cost Reduction. This matrix provides numerical scores for each technology based on these criteria, facilitating a quantitative comparison. For instance, AI-driven Investment Management receives high

scores in Scalability and Efficiency Improvement, whereas Chatbots for Customer Service stands out in Customer Satisfaction. By analyzing this matrix, you can pinpoint the most promising technologies based on your specific priorities. For example, if Cost Reduction is your main focus, Robotic Process Automation (RPA) for Back-office Tasks might be the most effective choice.

TABLE 5. Bi & Ci & Min (Ci)/Ci

	Bi	Ci	Min(Ci)/Ci
Chatbots for Customer Service	0.101509	0.0625	0.8125
Fraud Detection Systems	0.092957	0.066406	0.764706
Automated Loan Approval	0.096904	0.070313	0.722222
Personalized Financial Advising	0.090209	0.050781	1
Credit Scoring Models	0.092737	0.070313	0.722222
Anti-Money Laundering (AML) Systems	0.088571	0.0625	0.8125
Robotic Process Automation (RPA) for Back-office Tasks	0.096904	0.0625	0.8125
AI-driven Investment Management	0.090209	0.054688	0.928571
	min(Ci)*sum(Ci)	0.025391	6.575222

The table presents the results of a decision-making analysis using a combination of benefits (Bi) and costs (Ci) for various AI applications in banking. The key metrics include: Bi (Benefits): Represents the total benefit score of each AI application, reflecting its overall positive impact. Ci (Costs): Indicates the cost score associated with each application, which reflects the expense or resource requirement. Min(Ci)/Ci: This ratio compares each application's cost score to the minimum cost score across all options. A higher ratio indicates relatively lower cost compared to the minimum. For instance, Chatbots for Customer Service have a benefit score of 0.1015 and a cost score of 0.0625, yielding a ratio of 0.8125, meaning its cost is relatively high compared to the lowest cost option. Personalized Financial Advising scores the highest ratio of 1, indicating it has the lowest relative cost among the options. The final row, min(Ci)*sum(Ci), shows a combined value of 0.0254, which helps in normalizing and comparing the overall cost-effectiveness of the different applications. This approach assists in determining which AI solutions provide the best balance between benefits and costs.

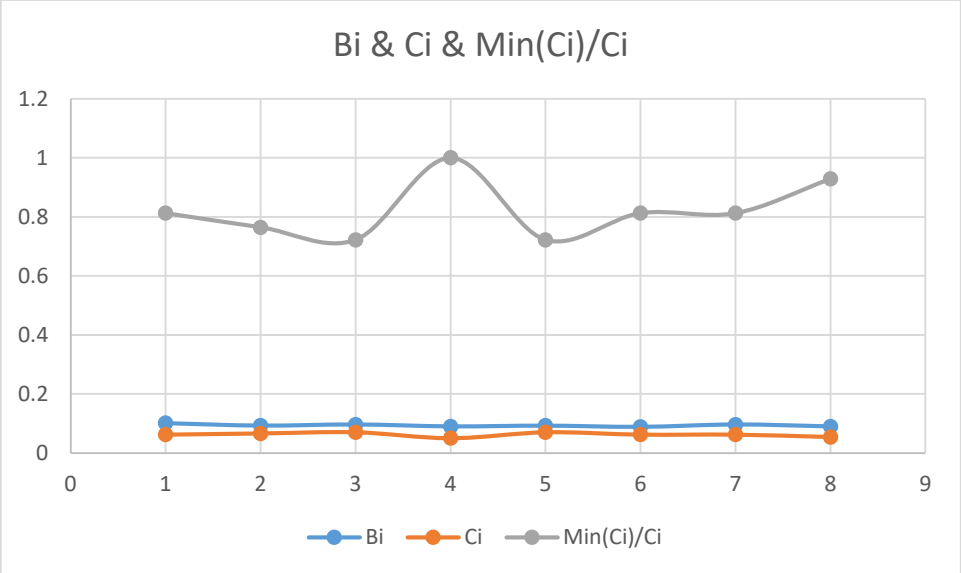

FIGURE 4. Bi & Ci &Min(Ci)/Ci

The Bi & Ci &Min(Ci)/Ci graph in Figure 4 provides a visual representation of the relationship between three variables: Bi, Ci, and Min(Ci)/Ci. Bi represents the Benefit associated with a particular decision or action. Ci represents the Cost associated with the same decision or action. Min(Ci)/Ci represents the Minimum Cost Ratio, which is the ratio of the minimum cost among all alternatives to the cost of the current alternative. The graph shows how these three variables interact. For example, as Bi increases, the Min(Ci)/Ci generally also increases, indicating that the benefit-to-cost ratio improves. However, there may be instances where Ci increases significantly, causing Min(Ci)/Ci to decrease, even if Bi remains high. This graph can be used to identify the

optimal decision or action by finding the point where Bi is maximized and Min(Ci)/Ci is minimized. This point represents the highest benefit-to-cost ratio among all available options.

TABLE 6. Qi and Ui % and Ui and Rank

	Qi	Ui %	Ui	Rank
Chatbots for Customer Service	0.163294	98%	0.982209	2
Fraud Detection Systems	0.151107	91%	0.908905	6
Automated Loan Approval	0.151824	91%	0.913216	5
Personalized Financial Advising	0.166252	100%	1	1
Credit Scoring Models	0.147657	89%	0.888154	8
Anti-Money Laundering (AML) Systems	0.150356	90%	0.904384	7
Robotic Process Automation (RPA) for Back-office Tasks	0.158689	95%	0.954509	4
AI-driven Investment Management	0.16082	97%	0.967329	3

Table 6 provides a detailed assessment of various AI applications in banking based on their overall effectiveness (Qi), utility percentage (Ui %), and utility index (Ui), including their respective rankings. This table helps in comparing the effectiveness and utility of each AI application in enhancing banking operations.

Personalized Financial Advising: It ranks highest with a Qi of 0.166252 and an Ui of 1 (100%). This indicates that Personalized Financial Advising provides the highest overall effectiveness and utility among the applications. Its top rank reflects its exceptional ability to deliver tailored financial advice, maximizing customer satisfaction and perceived value.

Chatbots for Customer Service: With a Qi of 0.163294 and an Ui of 0.982209 (98%), chatbots are highly effective and nearly as valuable as Personalized Financial Advising. They significantly improve customer service by providing instant responses and handling routine inquiries efficiently, contributing to high customer satisfaction and scalability.

AI-driven Investment Management: This application scores a Qi of 0.16082 and an Ui of 0.967329 (97%), placing it third. AI-driven Investment Management excels in delivering personalized investment advice and optimizing portfolios, which is highly valued by customers, although it ranks slightly below chatbots and personalized advising in terms of overall effectiveness.

Robotic Process Automation (RPA) for Back-office Tasks: RPA is ranked fourth with a Qi of 0.158689 and an Ui of 0.954509 (95%). It effectively automates repetitive and administrative tasks, enhancing operational efficiency and reducing costs, making it a strong performer in back-office operations.

Automated Loan Approval: It has a Qi of 0.151824 and an Ui of 0.913216 (91%), ranking fifth. Automated Loan Approval systems streamline the loan process, reducing approval times and operational costs, although it does not match the top performers in overall utility and effectiveness.

Fraud Detection Systems: Ranked sixth, with a Qi of 0.151107 and an Ui of 0.908905 (91%). These systems are crucial for identifying fraudulent activities, offering strong accuracy and efficiency in fraud prevention, but are slightly less effective in terms of overall utility compared to Automated Loan Approval.

Anti-Money Laundering (AML) Systems: Scoring a Qi of 0.150356 and an Ui of 0.904384 (90%), AML systems rank seventh. They play a critical role in regulatory compliance and preventing financial crimes, though their overall utility and effectiveness are slightly lower compared to other applications.

Credit Scoring Models: With a Qi of 0.147657 and an Ui of 0.888154 (89%), Credit Scoring Models are ranked eighth. They provide essential credit assessments, but their performance and utility are less impactful compared to other AI solutions.

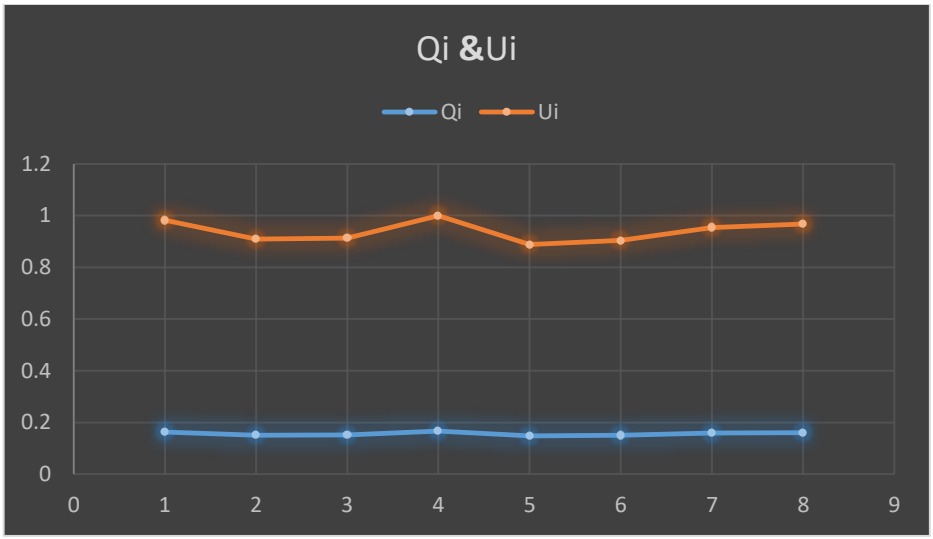

FIGURE 5. Qi & Ui

The Qi & Ui graph in Figure 5 shows the relationship between two variables: Qi and Ui. Qi likely represents a Quality metric, indicating the performance or effectiveness of something. Ui likely represents a Utility metric, indicating the usefulness or value of something. The graph illustrates how Qi and Ui fluctuate over time or across different scenarios. For example, Qi may increase while Ui decreases, suggesting that the quality has improved but the usefulness has diminished. Conversely, Qi and Ui may both increase, indicating a positive trend where both quality and utility are improving. The interpretation of this graph will depend on the specific context in which it is presented. However, it can be used to analyze the trade-offs between quality and utility and identify the optimal balance between the two.

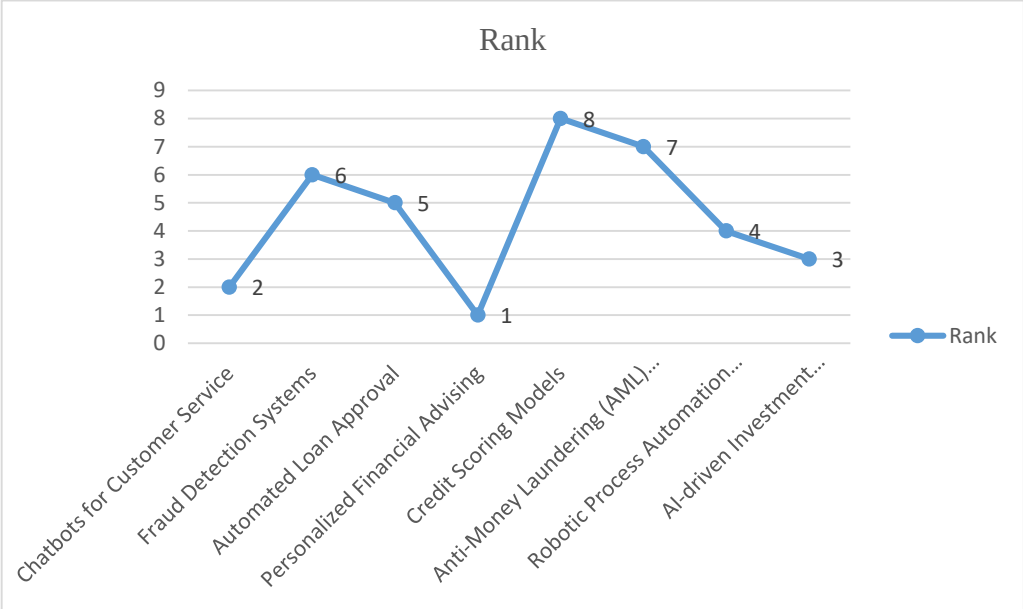

FIGURE 6. Rank

FIGURE 6 Rank shows The Chatbots for Customer Service is in 2nd rank, The Fraud Detection Systems is in 6th rank, The Automated Loan Approval is in 5th rank, The Personalized Financial Advising is in 1 rank, The Credit Scoring Models is in 8th rank, The Anti-Money Laundering (AML) Systems is in 7th rank, The Robotic Process Automation (RPA) for Back-office Tasks is in 4th rank and The AI-driven Investment Management is in 3rd rank.

4. CONCLUSION

Artificial Intelligence (AI) is profoundly transforming the banking industry, bringing significant advancements in efficiency, security, and customer experience. By integrating AI technologies into their operations, banks are

achieving remarkable improvements. One of the major benefits of AI in banking is its ability to enhance operational efficiency. AI algorithms process large volumes of data at incredibly fast speeds, automating routine tasks and reducing the need for manual input. This automation streamlines processes, decreases errors, and lowers operational costs. For example, AI systems can handle repetitive tasks such as data entry, transaction processing, and report generation with greater accuracy and speed than humans, allowing banking professionals to focus on strategic tasks and boosting overall productivity. AI also strengthens security in the banking sector. As cyber threats and fraud become more prevalent, banks are increasingly turning to AI for improved security measures. Technologies like machine learning and anomaly detection can identify unusual patterns and potential security breaches in real time. By continuously monitoring transactions and customer behavior, AI systems can more effectively detect and prevent fraudulent activities, safeguarding customers' financial assets and enhancing the bank's reputation. In terms of customer experience, AI is making a substantial impact. AI-powered chatbots and virtual assistants are revolutionizing customer service by providing instant support and resolving inquiries at any time. These tools handle a variety of interactions, from answering basic questions to offering detailed financial advice. By delivering personalized and timely assistance, AI improves customer satisfaction. Additionally, AI algorithms analyze customer data to offer tailored financial products and services, increasing the relevance and effectiveness of banking solutions. AI also enhances decision-making in banking. Traditional decision-making often depends on historical data and manual analysis, which can be slow and limited. In contrast, AI uses advanced analytics and predictive modeling to offer more accurate and data-driven insights. For instance, AI can assess creditworthiness by considering a broader range of factors beyond traditional credit scores, leading to more informed and fair lending decisions. This capability helps banks manage risks better and optimize their financial products. However, implementing AI in banking does come with challenges. Concerns about data privacy and security are significant, as AI systems handle sensitive customer information. Banks must implement strong data protection measures and adhere to regulatory standards to prevent breaches. Additionally, integrating AI technologies requires substantial investment in infrastructure and skilled personnel, which can be a barrier for smaller institutions. AI is driving transformative changes in the banking sector, offering benefits such as enhanced efficiency, improved security, and superior customer experiences. By leveraging AI, banks can streamline operations, prevent fraud, and deliver personalized services, gaining a competitive edge in a rapidly changing market. Nevertheless, addressing issues related to data privacy, security, and investment is crucial for the successful deployment and ongoing advancement of AI in banking. As AI technology continues to evolve, its potential to further revolutionize the banking industry remains substantial, promising even greater innovations and improvements in the future.

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