Enhancement Customer Loyalty Via Data Mining Techniques in Yemeni Banks: Review Study

Sultan Yahya Al-Sultan [*] and Ibrahim Ahmed Al-Baltah[1]

[1] **Department of Information Technology, Faculty of Computer Sciences and IT, University of Sana'a, Sana'a, Yemen**

*Corresponding author: sultan@su.edu.ye.com

ABSTRACT

Artificial intelligence (AI) significantly enhances our daily lives, driving many service and financial institutions to seek optimal utilization of it. This paper addresses the problem, which is the inability of some institutions, such as banks, to satisfy customers using outdated methods and solely focusing on acquiring new customers instead of prioritizing customer retention that would be more effective and profitable to them. The main object of this paper is to enhance the quality of service in banks by proposing an intelligent model that leverages customer data to improve services and foster customer loyalty. This paper was motivated by the limited research on customer churn in Yemen and the scarcity of simple intelligent models globally. The methodology employed in this paper includes an in-depth analysis of existing literature on customer churn. Finally, this paper provides a comprehensive and concise conclusion based on the findings.

1. INTRODUCTION

1.1. OVERVIEW

Banks have an impact on economic development because they are the primary financial institutions in every nation [1]. For the majority of financial transactions, banks have long been the primary responsible party, collaborating with clients and organizations [1]. Given that consumers are an organization's most valuable asset, keeping customers appears to be a fundamental need for all businesses [2]. The competitive environment in which various banks offer electronic banking services makes it more important than ever to retain customers [3]. Numerous banks offer their clients numerous benefits, such as the ability to check account balances, locate ATMs, transfer money, deposit checks, and much more [1].

1.2. CUSTOMER CHURN

Despite the many benefits and features that banks offer, the rate of customer churn is significantly higher than expected [1, 4]. Customer churn is the term used to de-scribe consumers breaking off their business relationship with a company that offers goods or services [2]. Churn prediction is identifying the clients who are most likely to discontinue their use of a service or leave entirely [5].

Customers are frequently motivated to leave an organization for both controllable and uncontrollable reasons [6]. According to [4, 7], among many other reasons, controllable factors include quality concerns, price changes, privacy concerns, competitive offerings that are attractive, low switching costs, general customer dissatisfaction, and many more. On the other hand, uncontrollable factors can be triggered by a variety of changes in customer circumstances, such as changes in personal lifestyle, challenges with family, job relocation, economic variations, international travel, death, and many more. Nevertheless, controlling churn is generally far more beneficial to customer retention than an expensive new customer, as studies [7, 8] have ensured. Increasing revenue and profitability is now a top priority for any business [9]. When current customers stop transacting, one of the reasons for a decline in profits is this [6]. Any organization loses out on possible sales

or cross-selling opportunities when a customer leaves [5]. If a client departs the institution without offering any guidance, the business might find it challenging to react and implement corrective measures. Even in developed and developing nations, numerous banks have experienced this crisis [7, 10]. As a result, banks should ideally take a proactive approach and identify potential churners before they leave [11].

Particularly, the exponential growth of data has encouraged numerous researchers worldwide to analyze their own dataset using more advanced methods such as artificial intelligence (AI) and machine learning technologies in an effort to better understand and clarify the factors that actually drive customers to use and retain their services [12, 13]. Due to the massive availability of large amounts of data and the necessity to transform such data into useful information and knowledge, data mining—the power tool of machine learning—has gained popularity in the research industry and in society at large in recent years [14, 15].

1.3. ARTIFICIAL INTELLIGENCE CHALLENGES AND APPLICATIONS

Artificial Intelligence (AI) plays a significant role in enhancing customer loyalty, but it also presents challenges [16]. Some of the challenges include ensuring data privacy and security, addressing biases in AI algorithms, building customer trust and acceptance, integrating AI systems into existing infrastructure, and continuous learning and flexibility [16]. These challenges require businesses to prioritize the ethical use of AI, invest in necessary skills and resources, and maintain transparency in AI-powered interactions. On the other hand, AI applications offer valuable techniques for enhancing customer loyalty. Personalized recommendations based on machine learning algorithms, sentiment analysis for understanding customer feedback, virtual assistants and chatbots for instant support, gamification to incentivize engagement, predictive analytics to predict customer behavior, social media engagement for building connections, and mobile apps with personalized experiences are examples of intelligent applications [17]. These techniques provide businesses with opportunities to personalize interactions, deliver targeted promotions, and create engaging experiences that strengthen customer loyalty.

This paper sheds light on the possibility of investing in and developing artificial intelligence methods for predicting customer behavior to retain them by using data that relates to them and the banks to which they belong. In addition to the desire to enrich this field with this new type of research that is concerned with enhancing customer loyalty in various service business institutions, especially banks, because of their great impact on the development and advancement of people.

The motivation of this paper is that, to the best of our

knowledge, there is a lack of studies that are mainly focused on customer churn in Yemen. Moreover, there are few studies around the world that display intelligent models' analyses using data mining techniques. Moreover, there is no paper or research implementing an artificially intelligent approach for enhancing customer loyalty via data mining techniques at Yemen Bank.

This paper addresses the problem, which is that many customers discontinue using the services and goods that banks offer. This is because banks do not know how to use artificial intelligence techniques to analyze the data at their disposal, which would help them improve the quality of services they provide to their clients. They also do not invest this data in winning new clients, which would increase their market share and increase their revenues.

The gap that this paper tries to fill is providing a comprehensive examination of the existing literature that wasn't sufficient and not clear enough to solve the problem of customer churn in easy steps. Therefore, the three most important objectives of this paper are:

- Propose an intelligent approach or model to improve the quality of services provided to bank customers and other financial institutions in all their forms, as the focus was on Yemeni banks in particular as an initial stage because of their impact on economic growth, by taking advantage of the huge amount of data stored in them related to customers through the use of methodologies and the science of artificial intelligence.
- Closing the gap by providing comprehensive information relating to artificial intelligence in this area of research.
- Minimizing the gap between banks and their customers, which makes them both satisfied and happy.

2. LITERATURE REVIEW

The prediction of customer turnover is a crucial aspect in many sectors since it offers useful information about consumer habits and future revenue estimates [9]. Additionally, it helps businesses identify areas where customer service may be lacking, enabling them to make the necessary improvements. Consequently, numerous authors have addressed customer churn analysis in different domains, including telecommunications, banking, insurance, subscription services, and more, in order to enhance customer loyalty [8, 18, 19]. In [20], it was shown that the idea that customers can choose not to do business with a provider by stopping purchases of the good or service offered by the company is known as customer churn, or simply "churn".According to [5], churn prediction has emerged as a key marketing campaign that major organizations and companies in developed countries use to survive in the highly competitive market.The two studies [2, 21] state that the ideas of

voluntary turnover, attrition, and defection are similar to those of customer churn. The researchers [5, 9, 20] have agreed that there may be variations in the definition of churn by company and industry. According to standard industry practices, [19, 22] have revealed that churn rates can vary by company and industry and can be measured at different times. [23] recommended that churn management is the process of keeping customers by using proactive strategies to counteract customer defection, turnover, and attrition. As mentioned in [1, 24], customers are ranked according to their likelihood of leaving the company; the customers with the highest probability scores are the ones targeted by incentive retention campaigns. A study by [25] discussed that, based on the idea that keeping customers is crucial to boosting business profitability, an increasing number of businesses across numerous industries are attempting to reduce customer attrition. According to [7], customer churn is therefore a crucial part of both customer lifetime value (CLV) modeling and customer relationship management (CRM). Generally speaking, controlling churn is far more beneficial to customer retention than spending money on the acquisition of new customers, as mentioned in [2, 4, 9]. Studies [1, 4] and [20] mentioned that maintaining a high level of customer loyalty can reduce the spread of unfavorable word of mouth, boost sales, and increase business profits. Furthermore, studies [20] and [8] discussed that by recognizing churners, businesses can implement targeted customer retention campaigns and provide exclusive incentives. The literature on customer churn encompasses two main streams of research. The first focus area investigates the different reasons behind churn. For instance, [26] identified a set of eight controllable and two uncontrollable drivers of telecommunications churn, analyzing their effects on Customer Lifetime Value (CLV). Similarly, [27] highlighted various factors contributing to customer attrition in the Nigerian telecom sector. The second focus area revolves around understanding predictive models and techniques used to forecast churn. Researchers in this field, such as [28], aim to develop accurate models that can proactively identify potential churners and facilitate intervention for customer retention. In the study of [28], explore diverse machine learning algorithms, statistical techniques, and data mining approaches to build effective predictive models for churn prediction.

In addition, a study [29] conducted a comprehensive analysis using a variety of data analysis techniques to examine the impact of sixty different customer churn indicators (behavioral and demographic variables) among gambling players. The results show that churn prediction is a valuable strategy to identify and profile those customers at risk. Furthermore, the performance of the ensembles is more robust and better than that of the single models. Similar studies have been conducted in various industries to understand the reasons for customer churn, as mentioned in studies [29] and [23].

The two studies [30, 31] insured that customer churn prediction models are essentially supervised classification models, primarily relying on machine learning. According to researchers, [7] and [22, 32, 33] Naive Bayes (NB), Logistic Regression (LR), K-Nearest Neighbors (KNN), Discriminant Analysis, Neural Networks (NN), Survival Analysis, Decision Trees (DTs), Support Vector Machines (SVM), Random Forests (RFs), Markov Chains, Hybrid Logit Model (LLM), and ensemble techniques such as bagging and boosting are common examples of supervised learning models that have been used to address the customer churn problem.

As shown in the study [34], there are two main categories of supervised classification techniques for customer churn prediction in predictive churn modeling that have emerged based on a comprehensive analysis of the existing literature: Decision trees and logistic regression both of these algorithm classes provide predictive and interpretable benefits. For comparison and result accuracy purposes, several studies mentioned the use of combined techniques, as stated in [34].

According to two studies [6, 35], there is no doubt about the financial benefits of retaining customers: (1) By focusing on satisfying the needs of current customers rather than pursuing riskier new customers, companies can increase their profitability. (2) Long-term clients can be a potential new business source if they are satisfied. (3) Long-term clients are typically less vulnerable to a competitive market, and due to the bank's experience, serving long-term clients becomes less expensive. (4) Losing clients results in lower sales and higher expenses associated with acquiring new ones.

In every industry, including banking, customer churn has become a significant concern. As stated in [9], banks have long sought to monitor customer interactions to identify potential attrition. A study by [36, 37] explored that customer churn modeling mainly focuses on identifying customers who are most likely to leave. In an increasingly competitive world, businesses have realized that their current clientele and their data are their most valuable assets.

The studies [36, 37] have stated that managing churn is crucial for retaining valuable clients. Businesses, including banks, insurance providers, and other service providers, are training their staff to be more customer- and service-oriented and developing plans to ensure that their clients stay with them. Furthermore, prior research [4, 6, 9] suggests that there are two focused approaches—proactive and reactive—for handling customer attrition.

The three research papers [4, 6, 9] conducted that the business proactively identifies potential churn customers and makes efforts to retain them by offering rewards. They found that accurate churn data is crucial, as companies lose money on customer churn if churn predictions

are off. Beside those studies, [38] summarized that customer churn prediction was energetic for all businesses as it provided deeper insights into their customer base and projected future revenue.

According to [6, 39], customer churn prediction can help companies identify and improve their weaknesses in customer service. According to some earlier studies [6, 40], there are two types of churns: voluntary and involuntary. Customers who are removed from a bank for any reason are considered to have committed involuntary churn. Voluntary churn occurs when customers stop using products or services willingly.

According to [18], it is crucial to handle a range of non-face-to-face visiting services and carry out marketing based on client attributes. As a result, anticipating customer attrition has emerged as a critical survival tactic in the home appliance rental industry.

[2, 21] and [41] improved that there are three primary strategies taken into consideration by many financial organizations in order to increase a company's competitiveness: (1) obtaining new customers; (2) augmenting sales to current customers; and (3) prolonging the customer retention period. Nevertheless, the third strategy proved to be the most successful when the significance of these three approaches was evaluated in relation to the return on investment (ROI). Their studies showed that predicting customer churn can help reduce its likelihood and benefit the business financially, which is the first step towards enhancing corporate competitiveness through the third strategy.

Numerous related studies, such as [6], have highlighted the necessity of customer retention strategies, contending that the expenses associated with keeping current customers are less than those associated with bringing in new ones. In [6], it was noted that businesses attempted to identify the causes of employee attrition and addressed these issues through reactive action plans. That study insisted that businesses can strategically use machine learning-based customer churn prediction models to determine in advance whether a particular customer is likely to leave a company or a bank and take appropriate action in time to prevent customer churn.

[9] and [5] agreed that, over the past few decades, the financial, insurance, and telecommunications industries have been the focus of most research on customer churn prediction. In the meantime, non-face-to-face marketing and customer management have grown in significance across all industries recently as a result of the protracted COVID-19. Interest in and needs for home appliance subscription services have grown along with the amount of time spent indoors.

To sum up, numerous studies have been trying to increase customer loyalty in different domains. The outcomes may vary depending on the industry's data. So, to increase loyalty in banking sectors, it is essential to predict customer churn using an artificial intelligence ap-

proach to determine whether customers will stop using products or services that the bank offers them.

3. THE PROPOSED MODEL

To the best of our knowledge, there is a lack of studies that are mainly focused on customer churn in Yemen. Moreover, few studies around the world display intelligent models for enhancing loyalty.

The model presented in this paper is illustated in Figure 1. It gives a general and detailed overview of all the stages that must be followed to harness artificial intelligence to improve customer loyalty in general and in banks in particular, which is composed of seven basic stages.
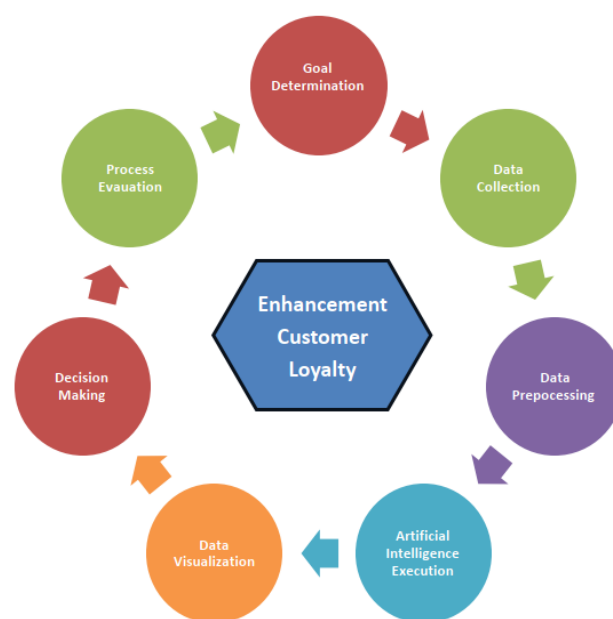

Figure 1. The Proposed Model

Many studies related to improving customer loyalty have used the general Crispy model, while others have built somewhat unclear business models. Therefore, this paper will attempt to present a simple model that contains seven basic stages through which customer satisfaction and loyalty in banks might be achieved through clear methodological steps. In Yemen, we have not seen any study that represents an intelligent model until now. This research paper benefited from previous studies in various sectors by designing an intelligent model that could help reduce the severity of the phenomenon of customer migration and its leakage from various financial and business institutions, such as banks.

- **Enhancing Customer Loyalty** Any bank that wants to enhance and increase the loyalty of its customers should follow the following seven stages:

    1. **Goal Determination**:The first step is to define clear and specific goals that aim to enhance

customer loyalty. These goals may include exploring new investment opportunities, launching innovative products, expanding into new markets, mitigating risks, providing user-friendly digital platforms, understanding and meeting customer needs and preferences, addressing customer issues promptly, and improving complaint resolution processes. By establishing strategic goals, the bank can focus its efforts on initiatives that foster customer loyalty and drive long-term success.

2. **Data Collection**:the bank must then collect the necessary data and information to achieve the desired goal so that it is in one dataset that is easy to deal with. Having a centralized and comprehensive dataset enables banks to gain insights into customer behavior, preferences, and patterns. This data can be used to develop targeted marketing campaigns, personalize product recommendations, and identify opportunities to enhance customer loyalty. Banks need to ensure data privacy and security while leveraging customer data for these purposes.

3. **Data Preprocessing**:banks in this stage can use AI tools and techniques to process datasets for cleaning and treatment. AI-based tools like OpenRefine, Trifacta Wrangler, and Talend Data Preparation automate the detection and handling of missing values, inconsistencies, and errors. Data visualization tools such as Tableau, Power BI, and Matplotlib aid in outlier identification, pattern detection, and exploratory data analysis. Statistical analysis tools like R, SPSS, and SAS incorporate AI algorithms for managing outliers, conducting tests, and calculating statistics. Machine learning algorithms in libraries like Scikit-learn, Caret, and Weka streamline outlier detection and exclusion through clustering, anomaly detection, and regression models. Database management systems like Oracle, MySQL, and Microsoft SQL Server provide AI-driven functionalities for efficient and accurate data cleaning, filtering, and querying.

4. **Artificial Intelligence Excution:** banks can use various artificial intelligence techniques to analyze customer datasets. Supervised learning algorithms (e.g., linear regression, logistic regression, decision trees, random forests, support vector machines, and neural networks) enable predictions and classifications for customer behavior, credit risk, fraud detection, and segmentation. Unsupervised learning algorithms (e.g., clustering, dimensionality reduction) identify patterns and clusters for customer segmentation, anomaly detection, and market basket analysis. Natural language processing techniques (e.g., recurrent neural networks, and transformer models like BERT and GPT) analyze customer feedback, sentiment, named entities, and topics. Recommender systems use collaborative and content-based filtering to provide personalized recommendations based on customer preferences and browsing history. Time series analysis models (e.g., ARIMA, exponential smoothing, and recurrent neural networks) forecast trends in time-dependent data like customer transactions or stock prices. Ensemble learning techniques (e.g., bagging, boosting) combine models for improved prediction accuracy.

5. **Data Visualization**:banks should thoroughly review the new data or information to identify any emerging patterns or insights. This process involves carefully examining the dataset, exploring relationships between variables, and conducting in-depth data analysis. By examining the data, banks can uncover hidden correlations, trends, or anomalies that may not have been initially apparent. This step allows for the discovery of novel patterns that can contribute to a deeper understanding of customer behavior, market dynamics, or potential risks. It enables banks to gain valuable insights and make informed decisions based on the newly discovered patterns in the analyzed data. Some suitable tools for data visualization in this context include Tableau, Power BI, and Matplotlib. Tableau is a popular data visualization software that allows users to create interactive dashboards, charts, and graphs. Power BI is a business intelligence tool by Microsoft that enables users to create interactive reports and dashboards, offering a wide range of visualization options. Matplotlib is a Python library widely used for creating static, animated, and interactive visualizations. These tools empower banks to visually represent data, enabling the identification of patterns, correlations, trends, and anomalies. By leveraging data visualization techniques, banks can gain valuable insights and make informed decisions based on the analyzed data.

6. **Decision Making**:in this stage, the bank can leverage the obtained insights and patterns to make efficient and effective decisions that aim to satisfy and retain its customers. With a deeper understanding of customer behavior, market trends, and potential risks, the bank can tailor its products, services, and marketing strategies to meet customer expectations and preferences. This may involve personalized recommendations, targeted advertising campaigns, improved customer service, or innovative product offerings. By leveraging the analyzed data and patterns, the

bank can make informed decisions that enhance customer satisfaction, loyalty, and overall business performance. This iterative process of analyzing data, discovering patterns, and making data-driven decisions contributes to the bank's ability to adapt and thrive in a dynamic and competitive market landscape.

7. **Process Evaluation**:in this stage, the bank should re-evaluate its overall objectives and re-newable goals to align with the identified patterns and customer needs. By incorporating the insights gained from the data analysis, the bank can assess its current strategies, identify areas for improvement, and refine its goals to better meet customer expectations. This involves a comprehensive review of the bank's products, services, customer experience, and business processes. By aligning the bank's objectives with the identified patterns and customer preferences, the bank can optimize its operations and prioritize initiatives that will best serve its customers while also reflecting the broader interests of the bank. This iterative process of re-evaluation ensures that the bank remains customer-centric and adaptable in an ever-evolving marketplace. To evaluate the bank's objectives and goals, several tools and techniques can be employed. Key Performance Indicators (KPIs) are measurable metrics that help assess the performance of specific objectives. Customer surveys and feedback provide valuable insights into customer needs and preferences. Business process analysis identifies inefficiencies and areas for optimization. Competitor analysis helps benchmark performance and identify opportunities for improvement. Financial analysis, including profitability and revenue growth assessment, evaluates the bank's success and guides decision-making for goal refinement.

4. CONCLUSION

Effective churn management is essential for companies, particularly banks, to retain customers and gain a competitive advantage. By identifying churners and implementing targeted retention strategies, banks can offer incentives to keep customers engaged, leading to potential profit increases of up to 85%. Artificial intelligence (AI) has proven valuable in customer retention and can be investigated for better outcomes. However, it is crucial to address the challenges associated with AI and ensure its responsible and ethical use. AI should be viewed as a tool that enhances human abilities rather than replacing them. This research proposes an intelligent model for bank managers in Yemen to increase customer loyalty and build trust. The model serves as a theoretical framework and will be further developed, executed, and evaluated using real data from any bank to validate its effectiveness.

REFERENCES

[1] M. A. Daqar, "The readiness of the palestinian banking industry to fintech era: Measuring the fintech ecosystem in palestine," Ph.D. dissertation, Magyar Agrár-és Élettudományi Egyetem, 2021.

[2] Y. Suh, "Machine learning based customer churn prediction in home appliance rental business," *J. big Data*, vol. 10, no. 1, p. 41, 2023.

[3] F. Ehsani, "Customer churn prediction from internet banking transactions data using an ensemble meta-classifier algorithm," 2022.

[4] R. Thomas, "A study of mobile banking in the state of kerala," 2019.

[5] R. Yahaya, O. A. Abisoye, and S. A. Bashir, "An enhanced bank customers churn prediction model using a hybrid genetic algorithm and k-means filter and artificial neural network," in *2020 IEEE 2nd International Conference on Cyberspac (CYBER NIGERIA)*, IEEE, 2021, pp. 52–58.

[6] D. Wadikar, "Customer churn prediction," 2020.

[7] İ. O. Yiğit and H. Shourabizadeh, "An approach for predicting employee churn by using data mining," in *2017 international artificial intelligence and data processing symposium (IDAP)*, IEEE, 2017, pp. 1–4.

[8] T. Vafeiadis, K. I. Diamantaras, G. Sarigiannidis, and K. C. Chatzisavvas, "A comparison of machine learning techniques for customer churn prediction," *Simul. Model. Pract. Theory*, vol. 55, pp. 1–9, 2015.

[9] P. Verma, "Churn prediction for savings bank customers: A machine learning approach," *J. Stat. Appl. & Probab.*, vol. 9, no. 3, pp. 535–547, 2020.

[10] D. L. García, À. Nebot, and A. Vellido, "Intelligent data analysis approaches to churn as a business problem: A survey," *Knowl. Inf. Syst.*, vol. 51, no. 3, pp. 719–774, 2017.

[11] A. Keramati, H. Ghaneei, and S. M. Mirmohammadi, "Investigating factors affecting customer churn in electronic banking and developing solutions for retention," *Int. J. Electron. Bank.*, vol. 2, no. 3, pp. 185–204, 2020.

[12] J. M. Al-Tarawneh, "Modelling the usage of mobile banking apps from the perspective of bank customers in jordan," Ph.D. dissertation, University of Gloucestershire, 2017.

[13] M. Antonijević, Đ. Ivanović, and V. Simović, "Adoption of mobile banking in the republic of serbia," 2021.

[14] S. T. Khine and W. W. Myo, "Customer churn analysis in banking sector," Ph.D. dissertation, MERAL Portal, 2019.

[15] M. Rahman and V. Kumar, "Machine learning based customer churn prediction in banking," in *2020 4th international conference on electronics, communication and aerospace technology (ICECA)*, IEEE, 2020, pp. 1196–1201.

[16] A. Kaplan and M. Haenlein, "Rulers of the world, unite! the challenges and opportunities of artificial intelligence," *Bus. Horizons*, vol. 63, no. 1, pp. 37–50, 2020.

[17] C. Guo and P. Jiao, "Evaluation and optimization of machine learning algorithms in personalized marketing," in *2024 Third International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)*, IEEE, 2024, pp. 1–5.

[18] I. Ullah, B. Raza, A. K. Malik, M. Imran, S. U. Islam, and S. W. Kim, "A churn prediction model using random forest: Analysis of machine learning techniques for churn prediction and factor identification in telecom sector," *IEEE access*, vol. 7, pp. 60 134–60 149, 2019.

[19] O. Çelik and U. O. Osmanoglu, "Comparing to techniques used in customer churn analysis," *J. Multidiscip. Dev.*, vol. 4, no. 1, pp. 30–38, 2019.

[20] C. C. Valluri, *The Many Types of Churn and Their Predictive Models*. Creighton University, 2019.

[21] E. Stripling, S. vanden Broucke, K. Antonio, B. Baesens, and M. Snoeck, "Profit maximizing logistic model for customer churn prediction using genetic algorithms," *Swarm Evol. Comput.*, vol. 40, pp. 116–130, 2018.

[22] M. Abiad, "Customer churn an omer churn analysis using binary logistic regression model," *BAU J. - Sci. Technol.*, vol. 1, 2020. [Online]. Available: https://doi.org/10.54729/2959-331X.1021.

[23] A. M. Almana, M. S. Aksoy, and R. Alzahrani, "A survey on data mining techniques in customer churn analysis for telecom industry," *Int. J. Eng. Res. Appl.*, vol. 4, no. 5, pp. 165–171, 2014.

[24] R. A. de Lima Lemos, T. C. Silva, and B. M. Tabak, "Propension to customer churn in a financial institution: A machine learning approach," *Neural Comput. Appl.*, vol. 34, no. 14, pp. 11 751–11 768, 2022.

[25] E. Domingos, B. Ojeme, and O. Daramola, "Experimental analysis of hyperparameters for deep learning-based churn prediction in the banking sector," *Computation*, vol. 9, no. 3, p. 34, 2021.

[26] M. Braun and D. A. Schweidel, "Modeling customer lifetimes with multiple causes of churn," *Mark. Sci.*, vol. 30, no. 5, pp. 881–902, 2011.

[27] A. A. Umar, I. Saaid, and A. A. Sulaimon, "Rheological and stability study of water-in-crude oil emulsions," in *AIP Conference Proceedings*, AIP Publishing, vol. 1774, 2016.

[28] A. Muneer, R. F. Ali, A. Alghamdi, S. M. Taib, A. Almaghthawi, and E. A. Ghaleb, "Predicting customers churning in banking industry: A machine learning approach," *Indonesian J. Electr. Eng. Comput. Sci.*, vol. 26, no. 1, p. 539, 2022.

[35] V. Kirmaci and H. Kaya, "Effects of working fluid, nozzle number, nozzle material and connection type on thermal performance of a ranque–hilsch vortex tube: A review," *Int. J. Refrig.*, vol. 91, pp. 254–266, 2018.

[36] A. Keramati, H. Ghaneei, and S. M. Mirmohammadi, "Developing a prediction model for customer churn from electronic banking services using data mining," *Financial Innov.*, vol. 2, pp. 1–13, 2016.

[29] K. Coussement and K. W. De Bock, "Customer churn prediction in the online gambling industry: The beneficial effect of ensemble learning," *J. Bus. Res.*, vol. 66, no. 9, pp. 1629–1636, 2013.

[30] Y. Richter, E. Yom-Tov, and N. Slonim, "Predicting customer churn in mobile networks through analysis of social groups," in *Proceedings of the 2010 SIAM international conference on data mining*, SIAM, 2010, pp. 732–741.

[31] M. H. Seid and M. M. Woldeyohannis, "Customer churn prediction using machine learning: Commercial bank of ethiopia," in *2022 International Conference on Information and Communication Technology for Development for Africa (ICT4DA)*, IEEE, 2022, pp. 1–6.

[32] V. Mahajan, R. Misra, and R. Mahajan, "Review of data mining techniques for churn prediction in telecom," *J. Inf. Organ. Sci.*, vol. 39, no. 2, pp. 183–197, 2015.

[33] V. Mahajan, R. Misra, and R. Mahajan, "Review on factors affecting customer churn in telecom sector," *Int. J. Data Anal. Tech. Strateg.*, vol. 9, no. 2, pp. 122–144, 2017.

[34] A. De Caigny, K. Coussement, and K. W. De Bock, "A new hybrid classification algorithm for customer churn prediction based on logistic regression and decision trees," *Eur. J. Oper. Res.*, vol. 269, no. 2, pp. 760–772, 2018.

[37] J. Kacprzyk, "Lecture notes in networks and systems," *(No Title)*, 2019.

[38] M. A. Nikolaevic, "Creation of a churn model for the company and processes for churn reduction," 2020.

[39] P. Lalwani, M. K. Mishra, J. S. Chadha, and P. Sethi, "Customer churn prediction system: A machine learning approach," *Computing*, vol. 104, no. 2, pp. 271–294, 2022.

[40] W. Park and H. Ahn, "Not all churn customers are the same: Investigating the effect of customer churn heterogeneity on customer value in the financial sector," *Sustainability*, vol. 14, no. 19, p. 12 328, 2022.

[41] C. I. Mbama, *Digital banking services, customer experience and financial performance in UK banks*. Sheffield Hallam University (United Kingdom), 2018.