ADOPTION OF BIG DATA IN IMPROVING EFFICIENCY AND CUSTOMERS EXPERIENCE IN BANKING SECTOR OF NIGERIA: A BOOST IN THE 21ST CENTURY

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ABSTRACT

The study was carried out to assess the extent to which big data is adopted to improve efficiency and customers experience in banking sector of Nigeria as a boost in the 21st century. The targeted population for the study comprised all the bankers in Nigeria. A stratified sampling technique was used in selecting 50 bankers from Akwa Ibom State, 50 bankers from Lagos State, and 50 Bankers from Abia State, each from 3 geographical zones in Nigeria (South South, South West, and South East respectively) and this gave a total sample size of 150 respondents. The instrument used for data collection was a structured questionnaire entitled "Big Data and Customer Experience in Banking Sector Questionnaire" (BDCEBSQ). Face and content validation of the instrument was carried out by an expert in test, measurement and evaluation and banking in order to ensure that the instrument has the accuracy, appropriateness and completeness for the study under consideration. The reliability coefficient obtained was 0.88 and this was high enough to justify the use of the research instrument. The researcher subjected the data generated for this study to appropriate statistical technique such as descriptive statistics to answer research questions. As regards the extent to which Big Data adoption improves operational efficiency in the banking sector of Nigeria the study showed that the highest percentage (24.00%) of the respondents identified with "Enhanced decision-making", while the least percentage (16.00%) were identified with "Innovation and digital transformation". For the extent to which Big Data analytics enhances customer experience and satisfaction in Nigerian banks, the highest percentage (16.00%) was recorded against "Personalization of Banking Services", while the least percentage (8.00%) was recorded against "Service Innovation and Product Development". The study came to the conclusion that adopting big data puts Nigerian banks in a position to adapt quickly to changing consumer demands and market competitiveness while promoting innovation in a range of financial services and products. One of the recommendation that banks should allocate resources to modern big data platforms and cloud-based solutions that can efficiently process large volumes of transactional and behavioral data in real time.

KEYWORDS: Big Data, Efficiency, Customers Experience, Banking Sector, Nigeria, 21st Century

INTRODUCTION

The 21st century has witnessed a dramatic transformation in the way information is generated, processed, and utilized across industries, with the banking sector standing at the forefront of this evolution. The rapid growth of digital technologies, mobile banking, and online financial services has led to an explosion of data, commonly referred to as "big data." This form of data, defined by its high volume, velocity, and variety, has become a critical resource for modern banks seeking to remain competitive and relevant in an increasingly digital economy. Rather than relying solely on traditional banking methods, financial institutions are now leveraging big data analytics to gain deeper insights into operations and customer behavior, thereby enhancing efficiency and strategic decision-making (McAfee & Brynjolfsson, 2012; Davenport, 2014).

In Nigeria, the adoption of big data in the banking sector has gained significant momentum, driven by increased internet penetration, the rise of financial technology (fintech) companies, and evolving customer expectations. Today's banking customers demand fast, convenient, and personalized services, pushing banks to rethink how they interact with their clientele. Through big data analytics, Nigerian banks can track customer preferences, predict financial needs, and tailor services to individual users, creating a more engaging and satisfying customer experience. This shift not only improves customer loyalty but also enables banks to respond swiftly to market changes and competitive pressures (Erevelles, Fukawa, & Swayne, 2016; Olanrewaju et al., 2020).

Beyond customer engagement, the integration of big data significantly enhances operational efficiency within Nigeria's banking industry. By utilizing advanced analytics tools, banks can streamline internal processes, detect fraudulent activities in real time, and optimize risk management strategies. These improvements reduce operational costs while increasing accuracy and reliability in service delivery. As a result, big data adoption represents a major boost for the Nigerian banking sector in the 21st century, positioning it for sustainable growth and innovation in a rapidly evolving global financial landscape (Chen, Chiang, & Storey, 2012; Kshetri, 2014).

Statement of the Problem

Despite the rapid growth of digital banking in Nigeria, many banks still struggle with inefficient service delivery and delayed transaction processing. The lack of full adoption of Big Data analytics limits banks' ability to effectively analyze customer behavior and predict financial needs. As a result, customers often experience poor personalization of services and inconsistent banking experiences across platforms. Furthermore, data fragmentation and weak integration systems hinder real-time decision-making in many Nigerian banks. These challenges reduce operational efficiency and negatively affect customer satisfaction and loyalty. Therefore, there is a need to examine how Big Data adoption can improve efficiency and enhance customer experience in Nigeria's banking sector.

Research Objective

1. To examine the roles of Big Data adoption improves operational efficiency in the banking sector of Nigeria.
2. To assess how Big Data analytics enhances customer experience and satisfaction in Nigerian banks.

Research Question

1. What are the roles of Big Data in improving operational efficiency in the banking sector of Nigeria?
2. How does Big Data analytics enhance customer experience and satisfaction in Nigerian banks?

LITERATURE REVIEW

Concept of Big Data

Big data refers to extremely large, complex, and rapidly generated datasets that cannot be effectively processed using traditional data management tools. It is commonly characterized by the “5 Vs": volume (large amounts of data), velocity (speed of data generation), variety (different data types such as text, images, and videos), veracity (data quality and reliability), and value (usefulness of data insights). Big data has become a critical component in modern decision-making across sectors such as healthcare, education, finance, and business, where organizations rely on advanced analytics to extract meaningful patterns and trends.

The tools and analytical techniques used to analyze and understand data are included in the notion of big data, which goes beyond data size. Large datasets may be handled effectively, and predictive and prescriptive analytics are supported by technologies like cloud computing, artificial intelligence, and machine learning. According to Khan et al. (2021), big data analytics allows organizations to improve performance, enhance customer experiences, and gain competitive advantages through data-driven strategies. In a similar vein, big data in education and research facilitates evidence-based policy formation, student performance monitoring, and individualized learning.

Concerns regarding data security, privacy, and ethical use have increased in tandem with the significance of big data in recent years. To guarantee responsible data management, regulatory frameworks and data governance regulations are becoming more and more important. As noted by Sivarajah et al. (2020), while big data offers significant opportunities for innovation, it also presents challenges related to data protection and ethical decision-making. All things considered, big data is a revolutionary idea that is changing how data is gathered, examined, and used in the digital world.

Concept of Efficiency

Efficiency refers to the ability to achieve maximum output with minimum input, ensuring optimal use of available resources such as time, money, labor, and materials. It is a fundamental concept in economics, management, engineering, and public administration, where it is used to evaluate how well resources are utilized to produce desired outcomes. In simple terms, efficiency is about doing things in the best possible way with the least waste.

Efficiency is frequently divided into several categories in modern research, such as technical, allocative, and operational efficiency. While allocative efficiency is concerned with using resources in a way that optimizes overall benefit or utility, technical efficiency concentrates on generating the most output from a given set of inputs. These elements continue to be crucial for assessing success in both the public and private sectors, according to Farrell (as explored in contemporary analysis). Recent research by Nguyen et al. (2021) highlights that efficiency measurement has evolved with the use of advanced analytical tools such as Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), which allow for more precise evaluation of organizational performance.

Furthermore, productivity and sustainability are intimately related to efficiency. Governments and organizations are working harder to increase efficiency in order to cut expenses, decrease their impact on the environment, and improve long-term performance. For instance, studies such as Zhu et al. (2020) emphasize the role of efficiency in achieving sustainable development by optimizing resource use and reducing waste. Efficiency is also linked to accountability and successful service delivery in public sector settings, especially in fields like healthcare and education.

Roles of Big Data in Improving Bankers Efficiency

Big data is now a vital instrument in contemporary banking, greatly increasing the productivity of bankers through better service delivery, automation, and decision-making. Banks can increase overall performance, cut expenses, and streamline operations by analyzing vast amounts of organized and unstructured data.

- **Enhanced decision-making**

Improved decision-making is one of big data's main functions. Bankers can evaluate both historical and real-time data using big data analytics to make quicker and more accurate financial decisions. It lowers uncertainty in banking operations by assisting with forecasting, performance evaluation, and strategic planning. This results in increased production and more effective resource allocation.

- **Fraud detection and risk management**

Risk management and fraud detection play a significant role as well. Big data helps banks avoid fraud and financial losses by enabling them to track transactions in real

time and spot odd trends. Additionally, advanced analytics models enhance loan default prediction and credit risk assessment, empowering bankers to make safer lending choices. This improves financial security and operational effectiveness.

- **Customer relationship management (CRM)**

Additionally, big data enhances CRM (customer relationship management). Banks are able to provide individualized services and goods by examining consumer behavior, preferences, and transaction history. This decreases the amount of time bankers spend managing complaints or manual processes while increasing customer happiness and loyalty. Bankers can now concentrate on more strategic work.

- **Process automation and operational efficiency**

Big data also facilitates operational efficiency and process automation. Data-driven systems can automate routine banking tasks including data entry, reporting, and consumer questions. This decreases operating expenses, expedites service delivery, and minimizes human error. As a result, bankers work less and are more productive.

- **Innovation and digital transformation**

Big data also supports innovation and the digital revolution of the financial industry. It makes it possible to create new financial products, digital banking systems, and financial inclusion plans. According to studies, big data greatly boosts innovation performance and service quality in banks, increasing total productivity and competitiveness.

Roles of Big Data in Improving Customer Experience in Banking Sector

Big data is essential to changing how banks engage with and provide services to their clients. Key roles are as follows, with detailed explanations:

- **Personalization of Banking Services**

Banks can provide customized services by analyzing consumer behavior, preferences, and transaction history thanks to big data. For instance, based on a person's unique financial habits, banks can suggest appropriate loan products, savings plans, or investment possibilities. This personalized approach increases customer satisfaction and loyalty (Kumar et al., 2021).

- **Predictive Analytics for Customer Needs**

Banks are able to foresee client wants by using predictive analytics. Banks can spot trends and provide prompt remedies, like lending facilities or financial advice, by looking at historical data. This proactive service enhances the overall customer experience (Chatterjee et al., 2022).

- **Improved Customer Support and Engagement**

Chatbots and virtual assistants, which offer immediate answers to consumer questions, are powered by big data. These systems run around the clock, guaranteeing that clients receive prompt support without any delays. This improves engagement and convenience (Alalwan et al., 2020).

- **Fraud Detection and Enhanced Security**

Big data analytics is used by banks to track transactions in real time and identify odd or suspicious activity. This keeps fraud at bay and safeguards client money. Enhanced security builds trust and confidence in banking services (Wei et al., 2021).

- **Faster and More Efficient Service Delivery**

By automating banking procedures, big data speeds up transactions and decreases wait times. Better experiences result from customers being able to swiftly and effectively accomplish tasks like account management, bill payment, and financial transfers.

- **Customer Insight and Decision-Making**

Banks may learn a lot about market trends and client expectations by examining enormous databases. These insights facilitate better decision-making and assist banks in creating better goods and services that satisfy client needs.

- **Omni channel Banking Experience**

Big data enables banks to combine client data from several channels, including branches, ATMs, online, and mobile apps. This ensures a seamless and consistent experience regardless of how customers interact with the bank (Jeble et al., 2020)

- **Service Innovation and Product Development**

Big data is used by banks to find market gaps and create cutting-edge financial products. New, user-friendly solutions are introduced and current services are improved by ongoing research of consumer input and usage trends.

Challenges of Adopting Big data in Improving Bankers Efficiency and Customer experience in Banking Sector

The banking industry's use of big data has greatly enhanced customer satisfaction and operational effectiveness. Nevertheless, banks have a number of obstacles when attempting to successfully use big data technology, despite their many advantages.

- **Data Privacy and Security Concerns**

Ensuring the security and privacy of client data is one of the most important problems. Banks are popular targets for cyberattacks because they handle sensitive financial and personal data. If appropriate security measures are not in place, the usage of big data raises the danger of data breaches. Data handling procedures are made more difficult by regulatory restrictions like data protection regulations. According to Sivarajah et al. (2020), managing data security while extracting value from large datasets remains a major concern for organizations.

- **High Implementation and Maintenance Costs**

Big data technology adoption necessitates significant financial investments in software, infrastructure, and qualified staff. Many banks find it difficult to pay for cloud services, data storage facilities, and sophisticated analytics tools, particularly in developing nations. Additionally, ongoing maintenance and system upgrades add to the financial burden (Khan et al., 2021).

- **Lack of Skilled Personnel**

The availability of qualified data scientists, analysts, and IT specialists is essential for the effective deployment of big data. However, there is a global lack of professionals with the know-how to handle and examine big datasets. This skills gap limits banks' ability to fully utilize big data capabilities (Mikalef et al., 2020).

- **Data Integration and Quality Issues**

Banks get information from a variety of sources, including branch operations, online platforms, ATMs, and mobile apps. It can be difficult and complex to integrate these disparate datasets into a single system. Inconsistent, incomplete, or inaccurate data can reduce the effectiveness of big data analytics and lead to poor decision-making (Ghasemaghaei, 2021).

- **Regulatory and Compliance Challenges**

The use of big data must adhere to stringent legal and ethical requirements because the banking industry is heavily regulated. Banks that operate worldwide face challenges due to regional variations in data storage, sharing, and usage regulations. Compliance with these regulations can slow down innovation and limit the use of big data technologies (Rizvi, 2022).

- **Resistance to Organizational Change**

Big data technology adoption frequently necessitates major adjustments to company procedures, culture, and structure. Because they don't comprehend new processes or are afraid of losing their jobs, employees may be reluctant to implement them. This

resistance can hinder the successful implementation of big data initiatives (Mikalef et al., 2020).

- **Complexity of Data Management**

It is technically challenging to manage massive amounts of both organized and unstructured data. For banks to effectively store, handle, and analyze data, they must invest in cutting-edge tools and systems. The sheer amount of data can become overwhelming and ineffective without appropriate data management techniques.

- **Ethical Issues and Bias in Data Use**

Algorithmic prejudice and data misuse are two ethical issues brought up by the usage of big data. Unfair actions, including discriminatory lending practices, can result from biased data. Ensuring transparency and fairness in data-driven decisions is a significant challenge for banks (Ghasemaghaei, 2021).

Mitigating strategies to the challenges of Adopting big data in Improving Bankers efficiency and customer experience in Banking Sector

In order to fully reap the benefits of big data in terms of improving customer satisfaction and bankers' productivity, banks must employ methods that effectively tackle the implementation issues.

- **Strengthening Data Security and Privacy Measures**

To safeguard sensitive client data, banks should make investments in cutting-edge cybersecurity solutions like encryption, multi-factor authentication, and real-time threat detection. Risks can also be reduced by putting strong data governance systems in place and abiding by data protection laws. According to Sivarajah et al. (2020), strong security infrastructure is critical for building trust and ensuring safe data utilization.

- **Investment in Scalable Infrastructure**

Banks can use scalable big data platforms and cloud-based solutions to save implementation costs by eliminating the need for large upfront investments. Cloud computing allows for flexible storage and processing capabilities, making big data adoption more cost-effective and efficient (Khan et al., 2021).

- **Developing Skilled Workforce**

Banks should fund training and development initiatives to give staff members access to technology and data analytics. The skills gap can be closed by working with academic institutions and employing data science specialists. Mikalef et al. (2020) emphasize that human capital development is essential for maximizing the value of big data analytics.

- **Improving Data Integration and Quality Management**

Banks should use integrated data management systems that combine data from multiple sources in order to address data fragmentation. To guarantee accuracy and consistency, procedures for data cleaning, validation, and standardization should be put in place. High-quality data enhances the reliability of analytics and decision-making (Ghasemaghaei, 2021).

- **Ensuring Regulatory Compliance and Ethical Standards**

Banks need to create compliance frameworks that are in line with national and international laws controlling the use of data. Big data can be used responsibly with the support of ethical standards, transparent data policies, and routine audits. This reduces legal risks and enhances customer confidence (Rizvi, 2022).

- **Promoting Organizational Change and Culture**

Reducing employee resistance requires effective change management techniques. Banks should promote a data-driven culture, educate employees about the advantages of big data, and involve them in implementation procedures. Leadership support plays a key role in encouraging adoption (Mikalef et al., 2020).

- **Adopting Advanced Data Management Tools**

Modern big data tools like machine learning, artificial intelligence, and automated data processing systems can simplify data management. These technologies increase the efficiency of managing large datasets and extracting useful information for better customer service.

- **Addressing Ethical Issues and Reducing Bia**

In order to identify and remove biases in decision-making processes, banks should regularly evaluate algorithms and create ethical AI frameworks. Ensuring fairness, accountability, and transparency in data usage is essential for maintaining customer trust and delivering equitable services (Ghasemaghaei, 2021).

METHODOLOGY

Ex-post-Facto design was adopted for this study. The targeted population for the study comprised all the bankers in Nigeria. A stratified sampling technique was used in selecting 50 bankers from Akwa Ibom State, 50 bankers from Lagos State, and 50 Bankers from Abia State, each from 3 geographical zones in Nigeria (South South, South West, and South East respectively) and this gave a total sample size of 150 respondents. The instrument used for data collection was a structured questionnaire entitled “Big Data and Customer Experience in Banking Sector Questionnaire” (BDCEBSQ). Face and content validation of the instrument was carried out by an expert in test, measurement and evaluation and banking in order to ensure that the instrument has the accuracy,

appropriateness and completeness for the study under consideration. The reliability coefficient obtained was 0.88 and this was high enough to justify the use of the research instrument. The researcher subjected the data generated for this study to appropriate statistical technique such as descriptive statistics to answer research questions.

RESULTS AND DISCUSSIONS

Research Questions 1: The research question sought to examine the roles of Big Data in improving operational efficiency in the banking sector of Nigeria. To answer the research question, percentage analysis was performed on the data, (see table 1).

Table 1:

Percentage analysis of the roles of Big Data in improving operational efficiency in the banking sector of Nigeria

Roles	Frequency	Percentage
Enhanced decision-making	36	24.00**
Fraud detection and risk management	33	22.00
Customer relationship management (CRM)	31	20.67
Process automation and operational efficiency	26	17.33
Innovation and digital transformation	24	16.00*
TOTAL	**150**	**100%**

** **The highest percentage frequency**

* **The least percentage frequency**

SOURCE: Field survey

The above Table 1 presents the percentage analysis of the roles of Big Data in improving Big Data adoption improves operational efficiency in the banking sector of Nigeria. From the result of the data analysis, it was observed that the highest percentage (24.00%) was recorded against "Enhanced decision-making", while the least percentage (16.00%) was recorded against "Innovation and digital transformation". This finding agrees with the opinion of Nguyen et al. (2021), who highlights that efficiency measurement has evolved with the use of advanced analytical tools such as Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), which allow for more precise evaluation of organizational performance.

Research Questions 2: The research question sought to examine the roles of Big Data analytics in enhancing customer experience and satisfaction in Nigerian banks. To answer the research question, percentage analysis was performed on the data, (see table 1).

Table 1:
Percentage analysis of the roles of Big Data analytics in enhancing customer experience and satisfaction in Nigerian banks

Roles	Frequency	Percentage
Personalization of Banking Services	24	16.00**
Predictive Analytics for Customer Needs	19	12.67
Improved Customer Support and Engagement	22	14.67
Fraud Detection and Enhanced Security	22	14.67
Faster and More Efficient Service Delivery	21	14.00
Customer Insight and Decision-Making	17	11.33
Omni channel Banking Experience	13	8.67
Service Innovation and Product Development	12	8.00*
TOTAL	**150**	**100%**

** **The highest percentage frequency**
* **The least percentage frequency**
SOURCE: Field survey

The above Table 2 presents the percentage analysis of the roles of Big Data analytics in enhancing customer experience and satisfaction in Nigerian banks. From the result of the data analysis, it was observed that the highest percentage (16.00%) was recorded against "Personalization of Banking Services", while the least percentage (8.00%) was recorded against "Service Innovation and Product Development". This finding agrees with the opinion of Kumar (2021) who sates that personalized approach increases customer satisfaction and loyalty.

CONCLUSION

In conclusion, the adoption of big data in Nigeria's banking sector represents a transformative force that is redefining both operational efficiency and customer experience in the 21st century. By harnessing the power of data analytics, banks are not only able to streamline processes, reduce costs, and enhance risk management, but also deliver personalized, fast, and reliable services that meet the evolving expectations of modern customers. This data-driven approach strengthens competitiveness, fosters innovation, and builds deeper customer trust and loyalty. As digitalization continues to expand, the effective integration of big data will remain a critical driver of sustainable growth and long-term success in Nigeria's banking industry, positioning it to thrive in an increasingly dynamic global financial landscape.

RECOMMENDATIONS

1. Banks should allocate resources to modern big data platforms and cloud-based solutions that can efficiently process large volumes of transactional and behavioral data in real time.

2. Partner with Fintech should access innovative data tools, analytics solutions, and market insights that can enhance operational efficiency and customer engagement.
3. There should be application of predictive modeling to detect fraudulent activities, assess credit risks, and optimize lending decisions, reducing financial losses and operational inefficiencies.

REFERENCES

Alalwan, A. A., Dwivedi, Y. K., & Rana, N. P. (2020). Digital banking adoption and customer experience. *International Journal of Information Management,* 50, 312–324.

Amer, A. A. (2024). Unveiling the Power of Big Data: A Comprehensive Review of its Role in the Banking Sector. *International Journal of Intelligent Computing and Information Sciences.*

Berrada, I. R., Barramou, F., & Alami, O. B. (2025). The Role of Big Data Analytics and Artificial Intelligence in Modern Banking. *International Journal of Environmental Sciences.*

Chatterjee, S., Rana, N. P., Tamilmani, K., & Sharma, A. (2022). The impact of big data analytics on customer relationship management. *Journal of Business Research*, 140, 387–399.

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. MIS Quarterly, 36(4), 1165–1188.

Chen, M., Mao, S., & Liu, Y. (2020). Big data: A survey. *Mobile Networks and Applications*, 25(1), 10–18.

Darwish, N. Y. (2025). Big Data Revolution: Enhancing Financial Planning and Budgeting Strategies. *International Journal of Multidisciplinary Applied Business and Education Research.*

Davenport, T. H. (2014). *Big Data at Work: Dispelling the Myths, Uncovering the Opportunities*. Harvard Business Review Press.

Erevelles, S., Fukawa, N., & Swayne, L. (2016). Big data consumer analytics and the transformation of marketing. *Journal of Business Research,* 69(2), 897–904.

Ghasemaghaei, M. (2021). Understanding the impact of big data on firm performance. *Information & Management,* 58(4), 103-420.

Gong, S. (2024). *Implementation of Big Data Techniques in Banking: Evidence from Real-time Fraud Detection and Customer Segmentation.* Advances in Economics, Management and Political Sciences.

Jeble, S., Dubey, R., Childe, S. J., (2020). Impact of big data and predictive analytics capability. *International Journal of Logistics Management,* 31(3).

Khan, N., Yaqoob, I., Hashem, I. A. T., (2021). *Big data: Technologies, opportunities, and challenges. The Scientific World Journal*.

Kshetri, N. (2014). Big data's impact on privacy, security and consumer welfare. *Telecommunications Policy*, 38(11), 1134–1145.

Kumar, V., Dixit, A., Javalgi, R. G., & Dass, M. (2021). Big data analytics in marketing. *Journal of Business Research,* 125, 23–37.

McAfee, A., & Brynjolfsson, E. (2012). Big data: The management revolution. Harvard Business Review, 90(10), 60–68.

Mhlanga, D. (2024). *The Role of Big Data in Financial Technology toward Financial Inclusion*. Frontiers in Big Data.

Mikalef, P., Pappas, I. O., Krogstie, J., & Giannakos, M. (2020). *Big data analytics capabilities and firm performance*. *Information & Management,* 57(2), 103169.

Nguyen, T. T., Nghiem, S., & Roca, E. (2021). Efficiency measurement in modern industries: Applications of DEA and SFA. *Journal of Productivity Analysis,* 56(2), 123–140.

Olanrewaju, T., Hossain, M. A., Whiteside, N., & Mercieca, P. (2020). Social media and entrepreneurship research: A literature review. *International Journal of Information Management,* 50, 90–110.

Rizvi, F. (2022). *Globalization and policy challenges*. Globalisation, *Societies and Education,* 20(1), 1–14.

Sahoo, B. K., & Tone, K. (2020). Decomposition of technical efficiency and its application. *European Journal of Operational Research,* 282(3), 1120–1132.

Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2020). *Critical analysis of Big Data challenges*. *Journal of Business Research*, 70, 263–286.

Wei, W., Li, J., Cao, L., (2021). *Online banking fraud detection*. Decision Support Systems, 138.

Zeroual, A. (2024). Using Big Data to Achieve Digital Transformation of Banking Services. *Al-Balqa Journal for Research and Studies*.

Zhu, J., Cook, W. D., & Seiford, L. M. (2020). Data envelopment analysis: A handbook of models and methods. *Annals of Operations Research*, 278(1), 1–9.