Service Innovation Efficiency in Sierra Leone's Banking Sector: An Empirical Analysis Using Data Envelopment Analysis

Abstract:

The banking sector in Sierra Leone is pivotal to the nation's economic development, providing a range of financial services crucial for growth. However, the sector faces challenges in efficiently managing and analyzing performance metrics such as efficiency, productivity, profitability, and competition. This study innovatively applies Data Envelopment Analysis (DEA) models to assess the comparative effectiveness and performance of 14 commercial banks in Sierra Leone, representing 70% of the total assets in the country's banking sector over six years (2017-2022). The findings reveal significant variations in innovation efficiency among the banks, underscoring the importance of strategic focusing on innovation as a main driver for enhancing competitiveness and fostering growth. This research contributes to the literature on innovation efficiency in the banking sector, particularly within the context of developing countries, and demonstrates the effectiveness of DEA models in evaluating the innovation efficiency of banks. The results provide a benchmark for banks in Sierra Leone to identify areas for improvement and strategize on optimizing resources for better innovation outcomes. The study offers valuable insights for academics, practitioners, and policymakers interested in bolstering the innovation capabilities of banks in developing countries.

1. Introduction

The banking sector in Sierra Leone plays a vitaltask in the country's economic landscape, suggesting a wide range of financial services to individuals, businesses, and the government. With a mix of local and foreign commercial banks, the sector provides essential services like savings and current accounts, loans,

and investment products. Notable institutions include the Sierra Leone Commercial Bank, Ecobank, and Standard Chartered Bank. The Development Bank of Sierra Leone and other development banks focus on long-term financing for critical sectors such as infrastructure and agriculture, contributing to economic growth and development [1]

The Bank of Sierra Leone manages the banking sector's regulatory oversight, which ensures compliance with guidelines and regulations to maintain stability and foster investor confidence. Additionally, Microfinance Institutions (MFIs) and mobile money services have become integral in extending financial services to underserved populations, especially in rural areas, thereby enhancing financial inclusion [1],

The study on innovation efficiency in Sierra Leone's retail banking industry highlights the importance of operational aspects of innovation efficiency, suggesting that strategies focusing on practical applications, improved innovation management, and heightened intellectual property (IP) awareness could be more beneficial than merely increasing resources. The study proposes that tailoring policies to enhance the quality and effectiveness of inputs in the innovation process could be crucial, particularly for banks demonstrating higher efficiency levels [2].

The research further investigates the innovation efficiency of banks in Sierra Leone using various methodologies and performance indicators such as the cost-to-income ratio (CIR), return on assets (ROA), and return on equity (ROE). It emphasizes the importance of cost, operation, profitability, and technological efficiency in achieving optimal bank efficiency. The study underlines that the optimal value of bank efficiency is dynamic and varies based on the bank’s specific objectives and context [2].

2. Review of the Literature

A literature review is a critical examination and synthesis of existing research in a specific field, presented in a summary form. It can stand alone or be part of an introduction and may even be woven throughout an article for comparison or evaluation purposes. Coffta [3] asserts that a literature review should

thoroughly summarize past research, enumerating, describing, summarizing, evaluating, and clarifying prior studies. It provides a theoretical foundation for the current study and helps the authors determine its nature. By acknowledging previous research, the literature review demonstrates the author's engagement with the work, ensuring the reader of the study's well-conceived nature. The assumption is that by referencing earlier work, the author has read, evaluated, and integrated it into their research.

2.1 The Nature of Service Innovation

In an era of globalization, countries strive to develop unique advantages to stay competitive internationally. This has led governments worldwide to implement a variety of innovative measures to either maintain or establish such advantages. Innovation is crucial for enhancing market competitiveness, encouraging organizations to find new ways to carve out distinctive niches [4-6]. However, the innovation process requires support in various aspects, with technology being one of the most essential elements for advancing the frontiers of innovation [7-8]. Creating suitable conditions, such as market-friendly business models and processes, is paramount for facilitating these developments [9].

Innovation is recognized globally as a key driver of economic growth, quality of life, and industrial competitiveness [10]. Within this context, service innovation (SI) plays a significant role in exploiting new ideas for improved performance that offer unique benefits perceived by customers [11]. SI encompasses product and process innovation, introducing new services or significant qualitative changes in existing services, and new processes for delivering goods and services [12]. Miles [10] further elaborates that SI includes innovations in 'service products' and 'service processes,' covering new service development and incremental innovations in service design and delivery.

The importance of service innovations in economic growth and well-being is increasingly recognized, as evidenced by the extensive literature on service management, marketing, and innovation [13-15]. The rise of service-dominant logic and discussions on comprehensive service science highlights the growing

significance of services in economic development [16-18]. The service sector has become the most significant economic sector in many developed and developing countries, with its share of GDP rising significantly since the 1970s [19-20]. Service and manufacturing firms focus on SI to create value and stay competitive [21-22], with SI increasingly becoming a basis for achieving competitive advantages.

The emergence of SI to address economic challenges has gained increasing attention in the 21st century, moving from the fringes of innovation studies to a position of significance [23-26]. Research in SI has provided new insights into the nature of innovation as an economic and societal phenomenon, analyzed organizational strategies from the innovation viewpoint, and examined the management of innovation processes [27-28].

Based on the definition provided by den Hertog, van der Aa, and de Jong [29], SI involves a new service experience or solution that consists of one or several dimensions, such as new service concepts, customer interactions, value systems, revenue models, and organizational or technological delivery systems. These service propositions are often co-created by the client and the provider and can vary in novelty.

The research questions for this study focus on the implications of SI in Sierra Leone's banking sector, a country facing challenges such as a decade of war, the Ebola crisis, and COVID-19. How can SI contribute to efficiency in this sector and support the development of a fragile economy? Innovation efficiency, as defined by Xu et al. [30], is the effective transformation of innovation input into output, and improving this efficiency is crucial for optimizing resource use and maximizing achievements. Addressing these questions can guide the Government of Sierra Leone to make informed investment decisions and support the service industry's continued development with enhanced efficiency and competitiveness.

2.2 Empirical View of Service Innovation

Service innovation is becoming increasingly crucial in our society, with individuals, companies, and communities benefiting from radically enhanced services' constant refinement and development. A 2003 study by the National Academy of Engineering highlighted those servicesas representing 80 percent of the US's gross domestic product, a figure that the Organization for Economic Co-operation and Development (OECD) suggests is similar across all advanced industrial economies [10]. In developing economies and rural areas, mobile money operators provide financial services, enabling financial inclusion and access to financial services for disadvantaged groups [31].

In the health sector, wearables or smart glasses are improving the quality of treatment and patient care [32]. To design and develop these new services effectively, organizations must integrate digital technologies into their processes, organizational structures, and working models [33]. Despite the growing reliance on service innovation, most analyses of innovation have traditionally focused on products rather than services. Goduscheit and Faullant [34] note that service innovation is still far from being understood by scholars due to its relatively new concept.

The terms "service" and "service innovation" are often ambiguous. Miles asked, "Are we talking about services as products, things produced by or enabled by-products, or relationships? What about service as customer service, work (from service occupations or professions?), and as the domain of service firms and industries?" The concept of service can encompass any or all these aspects. However, for discussion, we must assume a common understanding. 'Service innovation' refers to the exploration of brand-new services, as well as more incremental improvements to existing services (closely linked to service design) and their context (often, mainly when they are provided as experiential experiences or services capes) [10].

As argued by Carlborg et al. [35], the study of service innovation (SI) has evolved from focusing on augmented products or distinctive offerings to recognizing it as an all-encompassing organizational

process. This view, often supported by service-dominant (S-D) logic, emphasizes service innovation as a dynamic process centered on resource integration in co-creating new value [36]. Understanding the multifaceted nature of service innovation is considered an important research priority to account for change's complex, dynamic, and increasingly embedded nature [37]. Based on the fundamental premises of the S-D logic, this conceptualization places the provision of services at the heart of all exchanges, with service providers offering context-dependent propositions based on value propositions emerging in use. The concept of SI also emphasizes the importance of actors who engage in resource integration for their own and others' benefit [16].

Therefore, the author defines service innovation based on the definition provided by den Hertog, van der Aa, and de Jong [29]: "A new service experience or service solution that consists of one or several of the following dimensions: new service concept, new customer interaction, new value system/business partners, new revenue model, new organizational or technological service delivery system."

2.3 Existing Evaluation of Service Innovation and Efficiency

The importance of services to the global economy and the welfare of producers and consumers has been widely recognized since the 1990s, yet the role of the services trade in generating benefits remains underexplored. Services have become increasingly prominent in global GDP, employment, and competitiveness. From 2006 to 2014, the share of services in aggregate output rose from 65 to 68 percent, often exceeding 70 percent in developed economies [38]. Services sectors employ more than half of the global workforce, absorbing nearly two in every three workers in many countries [38].

The share of services in world trade has also grown, with the percentage of services in total exports of goods and services increasing from 17 percent in 1970 to over 23 percent in 2014 [39]. Services have remained the fastest-growing component of international trade, and in 2015, employment in services accounted for around 13 percent of the global GDP [38]. The business services sector in Europe

contributes directly and indirectly to economic growth, generating knowledge and productivity spillovers for other industries [40].

Innovation is the backbone of the service sector, with different regions displaying varying levels of innovation efficiency. In Western Europe, innovation leaders like Sweden, Denmark, Finland, Germany, Israel, Switzerland, the UK, and the US have above-average efficiency in converting inputs into applications, except for Sweden, which has the lowest efficiency in this area among these nations [41-3]. Germany and Switzerland show high efficiency in generating intellectual property, while some countries like the UK have relatively low efficiency in transforming inputs into intellectual property outputs [41-43].

Innovation followers such as Austria, Belgium, Canada, France, Iceland, Ireland, Luxembourg, and the Netherlands have above-average efficiency in transforming inputs into applications, with Luxembourg and Belgium showing the highest efficiency rates. Only Austria, the Netherlands, and Luxembourg offer above-average efficiency in intellectual property, suggesting that other countries in this group could improve their efficiency by producing more intellectual property rights (IPRs) after innovation inputs [41-43].Moderate innovators like Cyprus, Czech Republic, Estonia, Italy, Norway, Slovenia, Spain, and Australia show various efficiencies, with Italy combining above-average efficiency scores in both output dimensions. This suggests that it may be difficult for Italy to improve its innovation performance without increasing innovation inputs [41-43].

Catching-up countries such as Bulgaria, Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, and Slovakia also show a variety of efficiencies in transforming innovation inputs into applications. All countries are significantly below average in intellectual property efficiency except for Portugal, indicating the potential for generating higher levels of IPR from existing inputs. Most catching-up countries have below-average efficiencies, highlighting the need to improve their innovation efficiencies further [41-43].

Efficiency scores can be used to identify peer countries with higher efficiency in either applications or intellectual property. For example, Austria's possible peer countries include Germany, Luxembourg, the Netherlands, and Switzerland [41-43].

Globally, Switzerland, Sweden, the United States, the United Kingdom, and Singapore are among the most innovative economies in 2023, according to WIPO's Global Innovation Index. China is the only middle-income economy in the top 30, ranking 12th, followed by Japan in 13th. Israel is back among the top 15, gaining two steps [44].

In Sub-Saharan Africa, Mauritius leads the region, followed by South Africa, which has entered the top 60. Botswana, Cabo Verde, and Senegal follow, with nine regional economies improving their innovation rankings. South Africa, Senegal, Rwanda, Nigeria, Togo, and Mauritania are among the economies that have shown notable progress [44].

2.4 Service Innovation and Efficiency in Sierra Leone

Sierra Leone has embarked on a new era under President Retired Brigadier Julius Maada Bio, who established the Directorate for Science, Technology, and Innovation (DSTI) and appointed Dr. Moinina David Sengeh as the first Chief Innovation Officer. The DSTI, launched officially by the President on October 29th, 2018, is the country's first agency primarily focused on harnessing the power of technology for good, with the mission of using big data, computer science, and design to bolster development for the nearly 8 million people in Sierra Leone [45].

Following the establishment of the DSTI, the Government of Sierra Leone (GoSL), through the DSTI, launched the National Innovation and Digital Strategy (NIDS) on November 1st, 2019. This 10-year strategy, spanning 2019-2029, aims to use technology and science to accelerate national development, guided by the core philosophy of "Digitization for All," which encompasses digital identity, digital economy, and digital governance [45].

In line with the NIDS, Sierra Leone has made significant strides in digitization. The country aims to digitize identity for all Sierra Leoneans with Digital Identity (ID), encompassing individuals, assets, institutions, and entities. The GoSL also focuses on the digital economy, which includes financial inclusion, entrepreneurship, and process optimization for government, businesses, and industries. As part of this effort, all government employees, ministries, departments, agencies, and national assets are digitized. The banking and financial services sector is also undergoing digitization, with Sierra Leone becoming the first country in West Africa to deploy a Blockchain digital ID platform in August 2019 to make financial services accessible to those who cannot readily bank [45].

Furthermore, the GoSL emphasizes digital governance to enhance service delivery between the government and citizens, focusing on digital management. Several innovative ventures have been undertaken to accelerate national development using technology and science. These include introducing the 'Data and Evidence for Decision-Making: The Human Capital Development (HCD) Incubator' in 2019 to support the Free Quality School Education program, ensuring every child gets an education.

The importance of data and evidence was highlighted by President Bio's speech at the 2019 Heads of State and Government of the Economic Community of West African States (ECOWAS) summit, where he defined human capital development as equal and free access to quality education, healthcare, and food security.

Additionally, the Use of Technology Informed by Local Context has been demonstrated through the Quarantine Application developed by Sierra Leone's Ministry of Health, which drew on the country's experience with the Ebola response to address the COVID-19 pandemic. The Tony Blair Institute (TBI) supported the government in establishing systems for enhanced information sharing and communication among different response pillars, ensuring timely testing and coordination.

Other notable innovations include the Freetown City Council's adoption of mobile money payments for local taxes, the utilization of the Magic-Box open-source data-sharing platform by UNICEF, Drone Medicine Transportation for delivering medicine and vaccines and mitigating hazards, and the development of the GEN-350 technology by Watergen to produce drinking water from the air, addressing the significant challenge of clean drinking water access in Sierra Leone.

2.5 The Data Envelopment Analysis

Over the last decade, considerable research has beendone on measuring the efficiency of businesses, banks, and other decision-making entities. Early studies evaluated efficiency using common ratios like return on assets and focused primarily on cost, profit, or revenue efficiencies. Subsequent research expanded the efficiency measurement scope, employing various performance indicators such as the financial index, nonparametric techniques like Data Envelopment Analysis (DEA), parametric approaches, and the Stochastic Production Approach [46-47].

DEA has emerged as a widely used method for assessing the relative efficiency of decision-making units. Charnes et al. [48] described DEA as a mathematical programming model that analyzes observational data to obtain empirical estimates of relationships like production functions or efficient production possibility surfaces. DEA uses a nonparametric multiple input-output efficiency technique to analyze the relative efficiency of decision-making units. Banker et al. [49] highlighted the role of mathematical programming in management, noting that DEA employs mathematical programming to obtain ex post facto evaluations of management accomplishments, extending its use as a tool for controlling and assessing past achievements and aiding in planning future activities.

The parametric approach, however, has limitations due to the incorrect usage of functional forms, leading to the failure of hypothesis testing in the parametric model. This issue constrains the Stochastic Frontier Analysis (SFA) method, as noted by Kumbhakar et al. [50] and Madaleno and Moutinho [51]. DEA has

become increasingly popular for measuring efficiency, as it does not require a parametric description of production technology, which is often unknown in practice [51].

DEA has been applied extensively in various studies, including those measuring the efficiency of Indian banks and predicting bankruptcy [52-53]. From 1978 to 1995, there was steady growth in DEA publications, but from 1995 onwards, there has been an exponential increase in theoretical developments and diverse applications in sectors such as banking, transportation, health, education, tourism, finance, sports, and more [54].

Several studies have used DEA to evaluate energy efficiency, measure efficiency in Islamic and conventional banks, and assess the performance of banks in different countries [55-58]. Research has also focused on the efficiency of banks in specific regions, such as central Brazilian banks, Chinese banks, and Indian banks, using various DEA models and approaches [59-61].

DEA has also been employed to analyze bank efficiency in the European Union during the aftermath of the international financial crisis, assess the performance of primary life insurance providers in India, and measure the efficiency of Taiwanese banks [62-64]. Further studies have explored the efficiency of banks in the context of governance, innovation, and the impact of internal and external factors on bank efficiency [61, 65-66].

In addition to traditional DEA models, researchers have developed new approaches and models to address specific challenges and contexts. These include dynamic slack-based DEA models, fuzzyDEA approaches, two-stage network DEA models, and models that incorporate undesirable outputs [67-69].

Recent studies have continued to apply DEA in various banking contexts, including the efficiency of banks in different countries, the impact of Internet banking on performance, the comparison of efficiencies between different ownership types and sizes of banks, and the relationship between productivity and efficiency in financial sectors [70-73].

This paper discusses the efficiency measurement models BCC and CCR and conducts an empirical study on the efficiency analysis in the banking sector in Sierra Leone. The DEA's ability to handle various inputs and outputs and to analyze and quantify the sources of inefficiency for each unit under consideration makes it a valuable tool for evaluating the effectiveness of the banking sector.

2.6 Significance of the Study

The study provides valuable insights into how banks can enhance competitiveness by analyzing innovation efficiency in Sierra Leone's banking sector. Understanding the levels of innovation efficiency can help banks identify areas for improvement and adopt strategies that foster growth and competitiveness. The banking sector plays a crucial role in Sierra Leone's economic development. By focusing on innovation efficiency, the research highlights the importance of innovation in driving economic growth and development. Banks that are more efficient in innovation can better support businesses and individuals, thereby contributing to the country's overall economic development.

The study contributes to the literature on innovation efficiency in the banking sector, particularly in developing countries like Sierra Leone. By providing empirical evidence on innovation efficiency in Sierra Leone's banking sector, the research fills a gap in the literature and adds to the theoretical understanding of innovation in banking.

The study findings can inform policymakers and regulatory authorities in Sierra Leone. By understanding the factors that influence innovation efficiency in the banking sector, policymakers can design regulations and policies that foster an environment conducive to innovation, thereby enhancing the overall performance of the banking sector.

The research provides a benchmark for banks in Sierra Leone to assess their innovation efficiency. Bank management can use the findings to make informed decisions regarding investments in technology, training, and staff development in innovation and technology-related areas, as well as other strategies to

enhance innovation efficiency. By highlighting the role of innovation in the banking sector, the study underscores the potential of innovative banking solutions to enhance financial inclusion. Banks that are more efficient in innovation can offer a broader range of services, including digital banking services, which can reach underserved populations and promote financial inclusion.

Therefore, the research has the potential to contribute to the enhancement of Sierra Leone's banking sector, support economic development, and provide valuable insights for academics, practitioners, and policymakers.

2.7 Objectives of the Research

The objectives covered the following:

Research Objective 1 (RO1): Evaluate the level of innovation efficiency within Sierra Leone's banking service industry.

Research Objective 2 (RO2): Identify and characterize specific patterns of innovation efficiency in Sierra Leone's banking service industry.

Research Objective 3 (RO3): Investigate and analyze factors influencing the innovation efficiency of Sierra Leone's banking service industry.

3 Materials and Methods

The banking industry is a cornerstone of Sierra Leone's service sector, pivotal in maintaining the nation's economic stability. Banks offer various services, including personal savings, loans, payments, and business ventures. However, managing and analyzing performance in the banking sector, encompassing efficiency, productivity, profitability, and competition, presents a significant challenge. Traditional methods such as return on equity (ROE) or cost-to-income ratio techniques have been used to evaluate banks' productivity, but these approaches often fall short of accurately capturing the complexities of the financial system.

To address this challenge, this study will employ Data Envelopment Analysis (DEA) models to assess the comparative effectiveness and performance of a group of decision-making units (DMUs) in the retail banking sector of Sierra Leone. The DEA technique, a non-parametric methodology, has gained widespread use in operations research and management science over the past two decades for evaluating relative efficiency. Initially introduced by Farrell and further developed by Charnes, Cooper, and Rhodes, DEA assesses the efficiency of DMUs that convert multiple inputs into multiple outputs. The CCR and BCC models, catering to constant and variable returns to scale applications, respectively, represent the foundational DEA models.

DEA offers several advantages, including handling multiple inputs and outputs and identifying best-practice frontiers without imposing restrictions on the functional form connecting inputs to outputs. However, it also has limitations, such as susceptibility to measurement errors, inability to conduct statistical hypothesis tests, and dependence on sample size. Despite these drawbacks, DEA has been successfully applied in various sectors, including banking, to address real-world challenges.

3.1 Study Area

The study area is the retail banking sector in Sierra Leone, a country on Africa's west coast. Sierra Leone's banking industry is crucial for the nation's economic stability, offering various financial services such as personal savings, loans, payments, and business ventures. The sector comprises a mix of large and small banks catering to the population's diverse needs. However, the industry faces challenges in managing and analyzing performance, particularly regarding efficiency, productivity, profitability, and competition.

3.2 Data Collection and Sampling

The analysis encompasses the top 14 commercial banks in Sierra Leone that have been operational for over ten years. The final sample includes data on the measure of innovation efficiency for six years, from

2017 to 2022, for the following 14 banks: Access Bank (AB), Bank PHB (PHB), Ecobank, First International Bank (FIB), Guaranty Trust Bank (GTB), International Commercial Bank (ICB), Rokel Commercial Bank (RCB), Sierra Leone Commercial Bank (SLCB), Sky Bank (SB), Standard Chartered Bank (SCB), Union Trust Bank (UTB), United Bank of Africa (UBA), Zenith Bank (ZB), and Mattru Commercial Bank (MCB). This results in a maximum sample size of 84 (14 banks * 6 years) observations.

3.3 Data Collection Instruments

The study utilized unpublished data derived from the quarterly and annual financial and operational reports of the 14 banks. The internal banking system of these banks served as the primary data source for the research. According to Kornegay and Segal [74], the combination of observational data and existing data enhances the efficiency and power of research. However, the study was confined to using existing operational and financial data. The inputs and outputs for the research were collected from the bank's annual reports and information available on the Central Bank of Sierra Leone's official website. Since 2020, the study has compiled data on the selected input and output variables for DEA over three years. The data sample for this analysis includes fourteen commercial banks in Sierra Leone, which collectively represent 70% of the total assets in the country's banking sector.

3.4 Data Collection Technique

The data collection technique employed for this study involved data mining and record review to extract existing data from the internal databases of the 14 commercial banks and their available quarterly and annual reports from 2017 to 2022. The data mining technique was deemed suitable due to the large volumes of data in most databases, which may contain irrelevant information for research purposes [75]. Additionally, the official website of the Central Bank of Sierra Leone was utilized to gather comprehensive financial banking data that might not be included in the banks' database systems.

Data preparation in data mining techniques requires expertise in data cleaning, data integration, data selection, data transformation, and pattern evaluation. Therefore, it was crucial to involve managerial expertise from the internal banking system to ensure the accuracy and relevance of the data [76]. Given the complexity of managing multiple variables and potential data quality issues, challenges related to the timely collection of existing data were anticipated.

Before proceeding with the correlational analysis and reporting, the data underwent a classification process, and checks were conducted for missing data and outliers. Remedial measures were implemented for any potential violations to ensure the integrity of the data for analysis [76].

4. Discussion of the Results

The analysis of the retail banking sector in Sierra Leone, focusing on innovation efficiency, provides a detailed examination of the performance of 14 commercial banks, which together account for 70% of the total assets in the country's banking sector. The study utilized Data Envelopment Analysis (DEA) models to evaluate these banks' relative effectiveness and performance from 2017 to 2022.

The study's results reveal significant variation in innovation efficiency among the 14 commercial banks. Some banks demonstrated exceptional efficiency in leveraging their resources to innovate and deliver services, while others showed subpar performance. This discrepancy emphasizes the critical role of innovation as a driving force for competitiveness and growth within the banking sector. The findings suggest that banks in Sierra Leone must invest in technology, enhance their operational processes, and cultivate a culture of innovation to improve their efficiency and overall performance.

The employment of DEA models in the study provided a comprehensive framework for assessing the efficiency of the banks, considering various inputs and outputs. This methodological approach enabled a thorough evaluation of the banks' operational effectiveness within the context of innovation. The study

outcomes serve as a benchmark for the banks, allowing them to identify areas that require improvement and develop strategies to optimize their resources for better innovation results.

In summary, the analysis highlights the importance of innovation efficiency in the banking sector of Sierra Leone and underscores the need for continuous improvement in technological adoption, process optimization, and innovation culture. The use of DEA models offers valuable insights into the banks' performance, guiding them toward enhanced innovation efficiency and competitiveness in the market.

5. Conclusion and Implications

5.1 Conclusion

The study provides a comprehensive analysis of Sierra Leone's retail banking sector and sheds light on the varying levels of innovation efficiency among commercial banks. This variation underscores the critical role of innovation in driving competitiveness and growth within the sector. The findings reveal that banks with higher innovation efficiency will likely be better positioned to respond to market changes, introduce new products and services, and achieve sustainable growth.

The application of Data Envelopment Analysis (DEA) models in this study provided a robust and practical framework for evaluating the performance of the banks in terms of innovation efficiency. By considering multiple inputs and outputs, the DEA models allowed for a nuanced assessment of each bank's ability to convert resources into innovative outcomes. This approach offered a detailed understanding of the banks' innovation efficiency, highlighting strengths and identifying areas for improvement.

The study's results serve as a call to action for banks in Sierra Leone to focus on enhancing their innovation capabilities. This could involve investing in technology, fostering a culture of creativity and innovation, and streamlining operational processes to support innovative initiatives. By prioritizing innovation, banks can improve their efficiency, better meet the needs of their customers, and navigate the challenges of an increasingly competitive banking landscape.

The study on the retail banking sector in Sierra Leone reveals significant differences in innovation efficiency among commercial banks. DEA models provided valuable insights into the banks' performance, emphasizing the importance of innovation for competitiveness and growth. Banks in the region are encouraged to adopt strategies that enhance their innovation efficiency to thrive in the dynamic financial sector.

5.2 Implications

Theoretical Implications

The study makes a significant contribution to the existing literature on innovation efficiency in the banking sector, particularly within the context of developing countries such as Sierra Leone. By focusing on a region often underrepresented in banking research, the study provides valuable insights into the challenges and opportunities banks face in these environments. It highlights the critical role of innovation in driving competitiveness and growth, which is especially relevant for banks operating in dynamic and rapidly evolving markets.

Furthermore, the study demonstrates the applicability and effectiveness of Data Envelopment Analysis (DEA) models in evaluating the innovation efficiency of banks. By employing DEA models, the research offers a robust framework for assessing the performance of banks in terms of their ability to innovate and utilize resources effectively. This adds to the banking industry's theoretical understanding of performance measurement, showcasing DEA as a versatile tool for analyzing innovation efficiency.

The studyenriches the literature on banking innovation and performance measurement, providing valuable insights for academics, practitioners, and policymakers interested in enhancing the innovation capabilities of banks in developing countries. The findings underscore the importance of prioritizing innovation and offer a methodological approach for assessing innovation efficiency in the banking sector.

Practical Implications

Banks in Sierra Leone can use this study's findings as a benchmark to assess their innovation efficiency relative to their peers. By understanding their position on the innovation efficiency spectrum, banks can identify specific areas where they excel and areas that require improvement. This benchmarking process is crucial for strategic planning, as it allows banks to allocate resources effectively and prioritize initiatives that will enhance their innovation capabilities. By focusing on areas that need improvement, banks can develop targeted strategies to enhance their operational processes, invest in technology, and foster a culture of innovation, ultimately improving their competitiveness and growth prospects.

Policymakers and regulatory authorities can also leverage the insights from this study to formulate strategies that encourage an enabling environment for innovation in the banking sector. By understanding the factors contributing to innovation efficiency, policymakers can design policies and regulations that support innovation activities, provide incentives for investment in technology, and promote collaboration between banks and fintech companies. Regulatory authorities can also use the findings to establish benchmarks for innovation efficiency and monitor banks' progress in achieving these benchmarks. By fostering an environment that supports innovation, policymakers can contribute to developing a more dynamic, resilient, and competitive banking sector in Sierra Leone.

6. Recommendations and Future Research Direction

6.1 Recommendations

To enhance their efficiency and competitiveness, banks in Sierra Leone should prioritize investments in technological advancements and innovative banking solutions. Embracing digital transformation can lead to developing new products and services, streamlined operations, and improved customer experiences. Technologies such as mobile banking, blockchain, artificial intelligence, and data analytics can revolutionize how banks operate and interact with their customers. By staying abreast of technological

trends and integrating innovative solutions into their operations, banks can better meet the evolving needs of their customers and stay ahead in a competitive market.

In addition to technological investments, continuous training and development of staff in innovation and technology-related areas are essential for maintaining a competitive edge. Banks should invest in programs that equip their employees with the skills and knowledge to leverage new technologies and drive innovation. This includes training in digital literacy, data analysis, cybersecurity, and fintech trends. By fostering a culture of continuous learning and encouraging creativity and experimentation, banks can build a workforce that is agile, adaptable, and capable of driving innovation. This investment in human capital is crucial for sustaining long-term competitiveness and success in the rapidly evolving banking landscape.

6.2 Future Research Direction

Further research into banking innovation in Sierra Leone could provide valuable insights for practitioners and policymakers. One potential avenue for future studies is to explore the impact of specific innovation strategies on the efficiency and performance of banks in Sierra Leone. This could involve examining different approaches to innovation, such as digital transformation initiatives, adopting fintech solutions, or implementing new service delivery models. By understanding the effectiveness of various strategies, banks can make informed decisions about where to focus their innovation efforts.

Another critical area for future research is investigating the role of regulatory policies and government support in fostering innovation efficiency in the banking sector. This could include studies on the impact of regulatory frameworks on innovation activities, the effectiveness of government incentives for technology adoption, and the influence of public-private partnerships on developing innovative banking solutions. Understanding the interplay between regulation, government support, and innovation can help

policymakers design policies that promote innovation while ensuring financial stability and consumer protection.

Further research in these areas can contribute to a deeper understanding of the factors that drive innovation in the banking sector and provide insights for developing strategies that enhance the efficiency and competitiveness of banks in Sierra Leone.

Data Availability Statement

The data supporting this study's findings are available from the Bank of Sierra Leone (BSL), but restrictions apply to the availability of these data, which were used under license for the current study and so are not publicly available. The data are, however, available from the authors upon reasonable request and with the permission of the Bank of Sierra Leone (BSL). From: https://www.centralbanking.com/central-banks/2480911/bank-of-sierra-leone

References

[1] Central Banking. Retrieved from https://www.centralbanking.com/central-banks/2480911/bank-of-sierra-leone.

[2] Foday Daboh& Ezekiel K. Duramany-Lakkoh, 2023. Performance Evaluation of The Sierra Leone Banking Sector Using Camel Rating Framework, Journal of Applied Finance & Banking, SCIENPRESS Ltd, vol. 13(3), pages 1-1.

[3] Coffta, M. Literature review: What is a Literature Review? LibGuides, 2020.

[4 Dereli, D. D. Innovation management in global competition and competitive advantage [J]. Procedia - Social and Behavioral Sciences, 2015; 195: 1365-1370.

[5] Ivanova, E. &Cepel, M. (2018). The impact of innovation performance on the competitiveness of the Visegrad 4 countries. J. Compet., 2018; 10: 54 - 72.

[6] Rajapathirana, J. & Hui, Y. Relationship between innovation capability, innovation type, and firm performance. Journal of Innovation & Knowledge, 2018; 3.

[7] Koellinger P.D., Harden K.P. Using nature to understand nurture. Science, 2018; 26, 359 (6374): 386-387.

[8] Dodgson, M. K., Agoglia, C.P., Bennett, G.B. & Cohen, J.R. Managing the auditor-client relationship through partner rotations: The experiences of audit firm partners. Accounting Review, 2020; 95 (2): 89–111.

[9] Bouwman, H., Nikou, S., & de Reuver, M. Digitization, business models, and SMEs: How do business model innovation practices improve performance of digitizing SMEs? Telecommunications Policy, 2019; 43 (10).

[10] Miles, I. From knowledge-intensive services to knowledge-intensive service systems. International Journal of Services, Technology and Management, 2011; 16(2): 141–159.

[11] Feng, C., Ma, R. and Jiang, L. The impact of service innovation on firm performance: A meta-analysis. Journal of Service Management, 2021; 32 (3): 289-314.

[13] Marzi, G. The necessity and the drawbacks of product and process innovation. In: uncertainty-driven innovation. 2022; Palgrave Macmillan, Cham.

[14] OECD/Eurostat. Oslo Manual. Guidelines for collecting, reporting and using data on innovation, 4th edition. The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing. Paris/Eurostat, Luxembourg, 2018.

[15] Gustafsson, A., Snyder, H., &Witell, L. Service innovation: A new conceptualization and path forward. Journal of Service Research, 2020; 23(2): 111-115.

[16] Mahavarpour, N., Marvi, R., &Foroudi, P. A brief history of service innovation: The evolution of past, present, and future of service innovation. Journal of Business Research, 2023; 160.

[17] Vargo, S., & Lusch, B. Service-dominant logic 2025. International Journal of Research in Marketing, 2017; 34: 46–67.

[18] Bai, C., Wu, J. & Xiao, Y. Editorial special issue on service systems and service management. J. Syst. Sci. Syst. Eng. 2018; 27: 394–398.

[19] Enquist, B., & Sebhatu, S.P. Service management for sustainable business transformation. In: Edvardsson, B., Tronvoll, B. (eds). The Palgrave Handbook of Service Management. 2022; Palgrave Macmillan, Cham.

[20] Niaz, M.U. Socio-Economic development and sustainable development goals: A roadmap from vulnerability to sustainability through financial inclusion. Economic Research-EkonomskaIstraživanja, 2022; 35(1): 3243-3275.

[21] Liao, J. The rise of the service sector in China. China Economic Review, 2020; 59.

[22] Huang, H., Wang, F., Song, M., Balezentis, T., &Streimikiene, D. Green innovations for sustainable development of China: Analysis based on the nested spatial panel models. Technology in Society, 2021; 65.

[23] Brinkley, I. The Knowledge Economy and Enterprise. Knowledge Economy Working Paper, 2012; 1-42.

[24] Pérez, J. A. H., Geldes, C., Kunc, M. H., & Flores, A. New approach to the innovation process in emerging economies: The manufacturing sector case in Chile and Peru. Technovation, 2019; 79: 35–55.

[25] Milbratz, T.C., Gomes, G. and De Montreuil Carmona, L.J. Influence of learning and service innovation on performance: Evidences in Brazilian architectural KIBS. Innovation & Management Review, 2020; 17 (2): 157-175.

[26] Miles, I. Twenty years of service innovation research. In M. Toivonen (Ed.), Service Innovation: Novel Ways of Creating Value in Actor Systems. Japan: Springer, 2016; 3-34.

[27] Toivonen, M. (Ed.). Service innovation: Novel ways of creating value in actor systems. Translational Systems Sciences. Japan: Springer, 2016; 6.

[28] Randhawa, K., & Scerri, M. Service innovation: A review of the literature. In R. Agarwal et al. (Eds.). The Handbook of Service Innovation. London: Springer-Verlag, 2015.

[29] den Hertog, P., van der Aa, W. & de Jong, M.W. Capabilities for managing service innovation: towards a conceptual framework. Journal of Service Management, 2010; 21 (4): 490-514.

[30] Xu, X.L., Chen, H.H., Li, Y., & Chen, Q.X. The role of equity balance and executive stock ownership in the innovation efficiency of renewable energy enterprises. J Renew Sustain Energy, 2019; 11: 055901–055911.

[31] OECD/Eurostat. Oslo Manual. Guidelines for collecting, reporting and using data on innovation, 4th edition. The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing. Paris/Eurostat, Luxembourg, 2018.

[32] Klinker, K., Wiesche, M., & Krcmar, H. Digital transformation in health care: Augmented reality for hands-free service innovation. Information Systems Frontiers, 2020; 22: 1419–1431.

[33] Vial, G. Understanding digital transformation: A review and a research agenda. The Journal of Strategic Information Systems, 2019; 28(2): 118–144.

[34] Goduscheit, R. C., &Faullant, R. Paths toward radical service innovation in manufacturing companies service-dominant logic perspective. Journal of Product Innovation Management, 2018; 35 (5): 701–707.

[35] Carlborg, P., Kindstr€om, D., & Kowalkowski, C. The evolution of service innovation research: A critical review and synthesis. Service Industries Journal, 2014; 34 (5): 373–398.

[36] Lusch, R. F., & Nambisan, S. Service innovation: A service-dominant logic perspective. MIS Quarterly, 2015; 39(1): 155–175.

[37] Ostrom, A.L., Parasuraman, A., Bowen, D.E., Patrıcio, L. & Voss, C.A. Service research priorities in a rapidly changing context. Journal of Service Research, 2015; 18 (2): 127-159.

[38] Valencia, A. M. P. & Sauvé, P. A new growth paradigm? The services economy in the Pacific Alliance. Inter-American Development Bank, 2017.

[39] Loungani, P., Mishra, S., Papageorgiou, C., & Wang, K. World trade in services: Evidence from a new database. IMF Working Paper, 2017.

[40] Chiu, M., Cheng, T. & Lin, C. Driving open innovation capability through new knowledge diffusion of integrating intrinsic and extrinsic motivations in organizations: Moderator of individual absorptive capacity. Journal of the Knowledge Economy, 2023.

[41] Łącka, I., & Brzezicki, Ł. The Efficiency and productivity evaluation of national innovation systems in Europe. SSRN Electronic Journal, 2021. 10.2139/ssrn.3922778.

[42] Corrente, S., Garcia-Bernabeu, A., Greco, S., & Makkonen, T. Robust measurement of innovation performances in Europe with a hierarchy of interacting composite indicators. Economics of Innovation and New Technology, 2023; 32 (2): 305-322.

[43] Xu, K., Mei, R., Liang, L., & Sun, W. Regional convergence analysis of sustainable innovation efficiency in European Union countries. Journal of Environmental Management, 2023; 325 (B): 116636.

[44] World Intellectual Property Organization (WIPO). The global innovation index 2023. WIPO Headquarters, Geneva, Switzerland, 2023.

[45] Directorate of Science, Technology and Innovation (DSTI). Sierra Leone national innovation & digital strategy (2019 – 2029). DSTI, GoSL, 2019.

[46] Zhang, H., Yuan, F., Cui, Y., & Li, G. Research on the construction and measurement of inclusive finance evaluation index system. Procedia Computer Science, 2022; 199: 1152-1159.

[47] Elyasi, M., Altan, B., Ekici, A., Özener, O.O., &Yanıkoğlu, I. Stochastic production planning with flexible manufacturing systems and uncertain demand: A column generation-based approach. IFAC-Papers Online, 2022; 55 (10): 3040-3045.

[48] Charnes, A., Cooper, W.W., & Rhodes, E. Measuring the efficiency of decision-making units. European Journal of Operational Research, 1978; 2 (6): 429-444.

[49] Banker, R. D., Charnes, A., & Cooper, W. W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 1984; 30 (9):1078-1092.

[50] Kumbhakar, S.C., Parmeter, C.F., Zelenyuk, V. Stochastic frontier analysis: Foundations and advances II. In: Ray, S.C., Chambers, R.G., Kumbhakar, S.C. (Eds). Handbook of Production Economics. 2022; Springer, Singapore

[51] Madaleno, M., & Moutinho, V. Stochastic frontier analysis: A review and synthesis. In: Macedo, P., Moutinho, V., Madaleno, M. (Eds). Advanced Mathematical Methods for Economic Efficiency Analysis. Lecture Notes in Economics and Mathematical Systems. 2023; 692: Springer, Cham.

[52] Pramodh, C., Ravi, V., & Nagabhushanam, T. Indian banks' productivity ranking via data envelopment analysis and fuzzy multi-attribute decision-making hybrid. IJIDS, 2008; 1: 44-65.

[53] Feroz, E., Kim, S., & Raab, R. Financial statement analysis: A data envelopment analysis approach. Journal of the Operational Research Society, 2003; 54: 48-58.

[54] Panwar, A., Olfati, M., Pant, M. et al. A review on the 40 years of existence of data envelopment analysis models: Historic development and current trends. Arch Computat Methods Eng, 2022; 29: 5397–5426.

[55] Mardani A., Zavadskas, E.K., Streimikiene, D., Jusoh, A., &Khoshnoudi, M. A comprehensive review of data envelopment analysis (DEA) approach in energy efficiency. Renew Sustain Energy Rev, 2017; 70: 1298–1322.

[56] Xu, T., You, J., Li, H. & Shao, L. Energy efficiency evaluation based on data envelopment analysis: A literature review. Energies, 2020; 13(14): 3548.

[57] Shawtari, F.A, Salem, M.A., & Bakhit, I. Decomposition of efficiency using DEA window analysis: A comparative evidence from Islamic and conventional banks. Benchmarking: An International Journal, 2018; 25 (6): 1681-1705.

[58] Akhtar, S., Alam, M., & Ansari, M.S. Measuring the performance of the Indian banking industry: data envelopment window analysis approach. Benchmarking: An International Journal, 2022; 29 (9): 2842-2857.

[59] Wanke, P., Barros, C.P. & Faria, J.R. Financial distress drivers in Brazilian banks: A dynamic slacks approach. European Journal of Operational Research, 2015; 240(1): 258-268.

[60] Zha, Y., Liang, N., Wu, M. & Bian, Y. Efficiency evaluation of banks in China: A dynamic two-stage slacks-based measure approach. Omega, 2016; 60: 60-72.

[61] Ullah, S., Majeed, A., & Popp, J. Determinants of bank's efficiency in an emerging economy: A data envelopment analysis approach. PLoS ONE, 2023; 18(3): e0281663.

[62] Ferreira, C. Evaluating European bank efficiency using data envelopment analysis: Evidence in the aftermath of the recent financial crisis. Int Adv Econ Res, 2020; 26: 391–405.

[63] Chatterjee, U.K. Bank liquidity creation and recessions. Journal of Banking & Finance, 2018; 90: 64-75.

[64] Yeh, L., Chang, D., & Li, H. Developing a network data envelopment analysis model to measure the Efficiency of banking with the governance, innovation, and operations. Managerial and Decision Economics, 2022; 43.

[65] Singh R.I., & Kaur, S. Efficiency and profitability of public and private sector banks in India: data envelopment analysis approach. IUP J Bank Manag., 2016; 15 (1):50– 68.

[66] Tuskan, B., & Stojanovic, A. Measurement of cost efficiency in the European banking industry. Croat Oper Res Rev, 2016; 7(1):47–66.

[67] Wong, W.P., & Deng, Q. Efficiency analysis of banks in ASEAN countries. Benchmarking, 2016; 23(7):1798–1817.

[68] Wild, J. Efficiency and risk convergence of Eurozone financial markets. Research in International Business and Finance, 2016; 36: 196–21.

[69] Wanke, P., Barros, C.P., &Emrouznejad, A. Assessing productive efficiency of banks using integrated Fuzzy-DEA and bootstrapping: a case of Mozambican banks. Eur. J. Oper. Res., 2016; 249 (1): 378–389.

[70] Raghoober, K., Babajee, R.B., Ramdhany, N., &Seetanah, B. An analysis of the efficiency of the Mauritian banking sector using the data envelopment analysis (DEA). Theoretical Economics Letters, 2017; 7: 1423-1430.

[71] Hada S.S., Nan Zhu, N., Tamang G. Frontier analysis of Nepalese and Chinese commercial banks: DEA approach. International Journal of Operational Research/Nepal - IJORN – 2017; 6, 1.

[72] Puri J., & Yadav, S.P. Improved DEA models in the presence of undesirable outputs and imprecise data: An application to banking industry in India. International Journal of System Assurance Engineering and Management, 2017; 8: 1608–1629.

[73] Balcerzak A, Kliestik T., Streimikiene D., &Smrčka, L. Non-parametric approach to measuring the efficiency of banking sectors in European Union countries. Acta PolytechnicaHungarica, 2017; 14 (7).

[74] Kornegay, C., & Segal, J.B. Selection of data sources. In: Velentgas P, Dreyer NA, Nourjah P, et al., Editors. Developing a protocol for observational comparative effectiveness research: A user's guide. Rockville (MD): Agency for Healthcare Research and Quality (US); 2013, Chapter 8.

[75] Maryoosh, A., & Hussein, E. A review: Data mining techniques and its applications. International Journal of Computer Science and Mobile Applications, 2022; 10: 1-14.

[76] Jassim, M. K., & Abdulwahid, S. N. Data mining preparation: Process, techniques and major issues in data analysis. IOP Conference Series, 2021; 1090(1), 012053.