

Digital Banking and Operational Efficiency toward Bank Sustainability Performance

Max ABR. Soleman Lenggu^{1*}, Muhtarom² , Noah Rangi³ , Meriyana Sunengsih⁴ 

¹Department of Informatics Engineering, STIKOM Uyelindo Kupang, Indonesia

²Faculty of Law, Social and Political Sciences, Universitas Terbuka, Indonesia

³Pandawan Incorporation, New Zealand

⁴Alfabet Inkubator Indonesia, Indonesia

¹ms15260374@gmail.com, ²muhtarom@ecampus.ut.ac.id, ³no.rangi3@pandawan.ac.nz, ⁴meriyana@raharja.info

*Corresponding Author

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ABSTRACT

The rapid growth of digital banking has significantly transformed banking operations by enhancing efficiency and supporting sustainability-oriented practices aligned with the Sustainable Development Goals (SDGs), yet empirical evidence on its integrated impact remains limited, particularly in emerging markets. **This study aims to examine** the effect of digital banking adoption on operational efficiency and bank sustainability performance, while assessing the role of efficiency in strengthening sustainable outcomes. **A quantitative** panel data approach is applied using multi-year data from 25 commercial banks over the period of 2018–2023, where digital banking indicators, efficiency measures, and sustainability performance proxies are analyzed through regression-based panel data models with appropriate control variables. **The empirical findings reveal** that digital banking adoption positively and significantly improves operational efficiency, and higher efficiency levels are associated with enhanced sustainability performance, indicating that efficiency serves as a key mechanism linking digital transformation and sustainable banking performance. **This study concludes** that digital banking acts as a strategic enabler of sustainable banking by simultaneously improving operational efficiency and long-term sustainability performance, offering important implications for bank managers and policymakers in formulating data-driven digital transformation strategies that support sustainable financial development.

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1. INTRODUCTION

The rapid advancement of digital technologies has significantly transformed the global banking industry. Digital banking enables financial institutions to improve service accessibility, reduce operational costs, and enhance efficiency through automated processes [1, 2]. In addition, the banking sector is increasingly required to align its operational strategies with sustainability principles to support long-term environmental, social, and economic development. This alignment reflects the growing importance of integrating technological innovation with sustainable practices in modern banking systems.

Digital banking adoption has accelerated particularly in emerging markets, where financial institutions

are increasingly leveraging technology to improve financial inclusion and operational resilience. The expansion of mobile banking services, electronic payment systems, and digital lending platforms enables banks to reach underserved populations while reducing dependency on traditional branch-based services [3]. This transformation not only enhances service accessibility but also contributes to cost efficiency and resource optimization.

Furthermore, the growing emphasis on sustainability has encouraged banks to integrate Environmental, Social, and Governance (ESG) considerations into their operational strategies [4]. Digital banking supports sustainability initiatives by reducing paper consumption, minimizing transportation needs, and enabling remote service delivery. These developments highlight the importance of examining digital banking not only as a technological innovation but also as a strategic tool for sustainable financial development.



Figure 1. Digital Banking Contribution to SDGs

The integration of digital banking supports several SDGs, particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). Digital banking reduces paper-based transactions, minimizes physical infrastructure requirements, and improves resource efficiency through technology-driven operations [5]. As illustrated in Figure 1, digital transformation in banking contributes to sustainable development by promoting innovation, optimizing resource utilization, and reducing environmental impact.

Despite the growing relevance of digital banking and sustainability, empirical research examining their interconnected relationship remains limited. Previous studies have primarily focused on financial performance and operational efficiency, while the role of digital banking in enhancing sustainability performance has received less attention [6]. Therefore, this study investigates how digital banking adoption influences operational efficiency and sustainability performance, providing a comprehensive understanding of sustainable digital transformation in the banking sector.

2. RESEARCH METHOD

This study adopts a quantitative research approach to examine the relationship between digital banking adoption, operational efficiency, and bank sustainability performance. The research design utilizes panel data collected from commercial banks over multiple observation periods to capture both cross-sectional and time-series variations [7]. This approach enables a comprehensive analysis of how digital transformation influences operational efficiency and sustainability outcomes. The research method consists of literature review, conceptual framework development, data collection, variable measurement, and empirical analysis using panel regression techniques. By integrating these methodological components, the study ensures systematic examination of the proposed relationships and enhances the reliability and validity of the empirical findings.

2.1. Literature Review and Hypothesis Development

Digital banking has been widely recognized as a transformative force in the banking industry, enabling institutions to enhance service delivery, optimize internal processes, and respond to increasing digital competition. Prior studies suggest that digital banking adoption improves transaction speed, reduces operational costs, and increases accessibility through technology-driven platforms [8]. These improvements are closely associated with higher operational efficiency, which is considered a key determinant of bank performance in the digital era. Operational efficiency plays a strategic role in translating technological investments into tangible performance outcomes. From a sustainability perspective, efficiency improvements contribute to reduced resource consumption, lower emissions, and minimized reliance on physical infrastructure.

Previous literature indicates that efficient banking operations support sustainable business practices by aligning economic performance with environmental and social responsibilities [9]. However, empirical evidence that simultaneously links digital banking, operational efficiency, and sustainability performance remains limited, especially in emerging markets. Recent studies emphasize that digital transformation in banking improves operational agility, enhances risk management capabilities, and supports sustainable governance practices. Digital banking also contributes to environmental sustainability by minimizing physical documentation and reducing energy consumption. Based on this literature, digital banking is expected to enhance operational efficiency, which in turn improves bank sustainability performance.

2.2. Conceptual Framework

This study adopts a conceptual framework that positions digital banking as a key explanatory variable influencing operational efficiency and bank sustainability performance. The adoption of digital banking technologies enables financial institutions to optimize internal processes, reduce operational costs, and enhance service accessibility. Operational efficiency is also assumed to act as an intermediate mechanism through which digital banking contributes to sustainability outcomes [10]. This framework reflects the theoretical perspective that technological innovation improves internal processes, which subsequently enhances long-term sustainable performance. By integrating digital solutions into core banking activities, institutions can improve productivity while simultaneously supporting environmentally and socially responsible practices.

The conceptual framework also considers the dynamic interaction between technological innovation and sustainability objectives. Digital banking facilitates continuous monitoring of operational performance, enabling banks to adjust strategies in response to sustainability targets. This interaction strengthens the role of operational efficiency as a mediating factor in achieving sustainable banking performance [11]. Furthermore, digital platforms support data-driven decision making, allowing banks to evaluate performance indicators more effectively and align operational strategies with sustainability goals. The integration of digital technologies also reduces reliance on physical infrastructure and paper-based processes, contributing to resource efficiency and environmental sustainability.

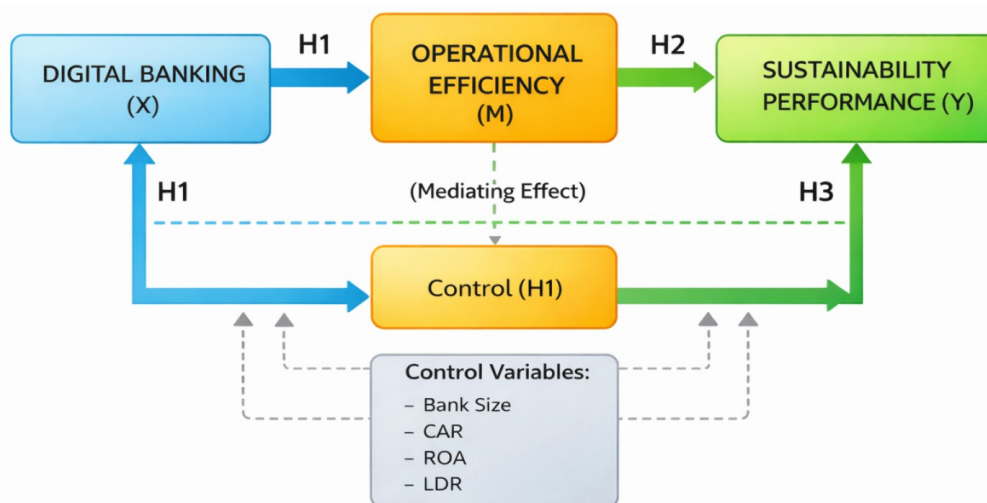


Figure 2. Conceptual Framework of the Study

Figure 2 presents the conceptual framework of this study, depicting the direct relationship between digital banking and sustainability performance as well as the indirect relationship mediated by operational efficiency. The framework illustrates that digital banking improves operational efficiency through automation, improved coordination, and optimized resource utilization. These efficiency gains subsequently enhance sustainability performance by reducing environmental impact and supporting responsible banking practices [12]. The dashed arrow indicates the mediating role of operational efficiency in linking digital banking adoption and bank sustainability performance, highlighting the importance of efficiency as a bridge between digital transformation and sustainable banking outcomes.

2.3. Data and Sample Selection

This study employs a quantitative research design using panel data collected from commercial banks over a multi-year observation period. The sample consists of banks that have consistently published annual reports and sustainability-related disclosures, ensuring data availability and comparability across years [13]. Panel data analysis allows the study to capture both cross-sectional and time-series variations, improving the robustness of the empirical results and providing a more comprehensive understanding of the relationship between digital banking adoption, operational efficiency, and sustainability performance. By combining data across multiple periods and institutions, the study minimizes short-term fluctuations and captures long-term trends in digital transformation within the banking sector. This approach also enhances the generalizability of the findings by incorporating diverse banking characteristics and operational conditions across the observed sample.

Banks included in the sample are selected based on predefined criteria, such as data completeness, operational continuity during the study period, and availability of sustainability-related information. This approach minimizes potential bias arising from missing data and ensures that the observed effects of digital banking adoption and efficiency are not driven by temporary or exceptional conditions [14]. Additionally, the selection criteria ensure that only banks with consistent reporting standards are included, improving data reliability and measurement consistency. The use of these criteria strengthens the validity of the empirical analysis and supports more accurate estimation of the relationships among the variables. Overall, the sample selection process is designed to ensure representativeness, enhance data quality, and provide a solid foundation for examining the impact of digital banking on operational efficiency and sustainability performance.

2.4. Variable Measurement

Digital banking is measured using key indicators that reflect both adoption and usage of digital platforms, including online banking services, mobile banking penetration, and the intensity of digital transactions [15]. Operational efficiency is proxied through commonly used financial ratios in banking studies, such as the cost-to-income ratio and other efficiency-related metrics that indicate how effectively banks utilize their resources. Meanwhile, bank sustainability performance is assessed using indicators derived from ESG disclosures or sustainability reports, capturing the extent to which banks integrate sustainable practices into their operations and support long-term value creation beyond financial performance.

Table 1. Measurement of Research Variables

Variable	Proxy / Measurement	Source
Digital Banking	Digital transaction ratio, mobile banking usage	Annual reports
Operational Efficiency	Cost-to-income ratio	Financial statements
Sustainability Performance	ESG disclosure index	Sustainability reports

Table 1 presents the measurement of research variables used in this study, including digital banking, operational efficiency, and bank sustainability performance, along with their respective proxies and data sources. Digital banking is measured using indicators that reflect the extent of banks' adoption and utilization of digital platforms, such as digital transaction intensity and mobile banking usage, which capture the level of digital transformation in banking operations [16]. Operational efficiency is proxied by the cost-to-income ratio, a widely used indicator in banking studies that reflects the effectiveness of banks in managing operating expenses relative to operating income. A lower cost-to-income ratio indicates higher efficiency, suggesting that banks are better able to optimize resources and control operational costs. Bank sustainability performance is measured using an ESG disclosure index derived from banks' sustainability reports and annual disclosures.

This proxy captures banks' commitment to ESG practices and reflects their alignment with sustainable development objectives. Overall, Table 1 summarizes the operationalization of key variables and ensures consistency, reliability, and comparability in the empirical analysis [17].

2.5. Control Variables

In addition to the main variables, this study incorporates several control variables to enhance the robustness and validity of the empirical model. The inclusion of control variables is essential to account for heterogeneity across banks, particularly in terms of structural and financial characteristics that may independently influence both operational efficiency and sustainability performance [18]. Specifically, factors such as bank size, capital adequacy, liquidity levels, and profitability are considered, as these elements often shape managerial decisions, risk tolerance, and resource allocation. Larger banks, for instance, may benefit from economies of scale and more advanced technological infrastructure, while well-capitalized institutions tend to have greater resilience and capacity to invest in sustainable initiatives. By controlling for these variables, the study aims to minimize potential omitted variable bias and ensure that the estimated effects of digital banking adoption are more accurately captured. Consequently, the model is better positioned to isolate the true relationship between digital transformation and performance outcomes, leading to more reliable and generalizable findings.

Table 2. Control Variables Used in the Study

Variable	Proxy / Measurement	Description
Bank Size	Log of total assets	Controls scale effect
Capital Adequacy	Capital Adequacy Ratio (CAR)	Measures financial stability
Profitability	Return on Assets (ROA)	Controls performance level
Liquidity	Loan-to-Deposit Ratio (LDR)	Measures liquidity condition

Table 2 presents the control variables used in this study, including bank size, capital adequacy, profitability, and liquidity. Bank size is measured using the logarithm of total assets to capture scale-related efficiency differences among banks. Capital adequacy, represented by the CAR, reflects financial stability and risk absorption capacity. Profitability is measured using ROA, which indicates the bank's ability to generate earnings from its assets. Liquidity is proxied by the LDR, reflecting the bank's ability to manage funding and lending activities. The inclusion of these control variables improves the reliability of the empirical model and strengthens the validity of the analysis [19].

2.6. Empirical Model and Data Analysis

To examine the relationships between digital banking adoption, operational efficiency, and sustainability performance, this study employs panel data regression techniques that combine both cross-sectional and time-series observations. This approach is particularly suitable as it enables a more comprehensive analysis of variations across banks as well as changes over time, thereby improving the depth and accuracy of the empirical investigation [20]. The estimation process utilizes either fixed-effects or random-effects models, selected based on diagnostic procedures such as the Hausman test to ensure the most appropriate model specification. By applying these techniques, the study effectively controls for unobserved heterogeneity and bank-specific characteristics that could otherwise bias the estimation results. Furthermore, panel data analysis enhances statistical efficiency, reduces multicollinearity issues, and provides more reliable coefficient estimates, strengthening the overall validity of the findings.

The empirical model is designed to capture both the direct and indirect effects of digital banking on sustainability performance, with operational efficiency positioned as a mediating variable. This framework allows the study to assess not only whether digital banking improves sustainability outcomes, but also how such improvements occur through enhanced efficiency. In addition, a set of control variables is incorporated to account for differences in financial conditions, such as bank size, capital structure, and profitability, which may influence performance outcomes [21]. To ensure the robustness and consistency of the results, additional tests are conducted, including alternative model specifications and sensitivity analyses. The findings derived from this empirical approach provide strong evidence on the role of digital banking in driving efficiency gains and supporting sustainable banking practices, offering a comprehensive understanding of how digital transformation contributes to long-term performance and resilience in the banking sector.

3. FINDINGS

This study identifies several key findings derived from the empirical analysis of digital banking adoption, operational efficiency, and bank sustainability performance, providing a more comprehensive understanding of how digital transformation reshapes the banking sector [22]. The results demonstrate that digital banking plays a significant role in enhancing operational efficiency by streamlining processes, optimizing resource utilization, and reducing operational costs through automation and integrated digital systems. At the same time, the findings reveal that digital banking contributes meaningfully to sustainability performance by supporting environmentally responsible practices, such as minimizing paper usage, lowering energy consumption, and promoting more transparent and accountable governance mechanisms. Each finding reflects a distinct dimension of the relationship between digital adoption and banking performance, highlighting not only efficiency gains but also the strategic alignment of digital transformation with sustainability objectives, particularly those associated with the SDGs. Furthermore, the analysis emphasizes that the impact of digital banking extends beyond internal operational improvements to broader sustainability outcomes, as it enables banks to reduce physical resource dependency, enhance service accessibility, and strengthen stakeholder trust through improved transparency. Collectively, these findings suggest that digital banking should not be viewed merely as a technological advancement for efficiency enhancement, but rather as a critical driver of sustainable banking transformation that supports long-term value creation and resilience within an increasingly digital and sustainability-oriented economic landscape [23].

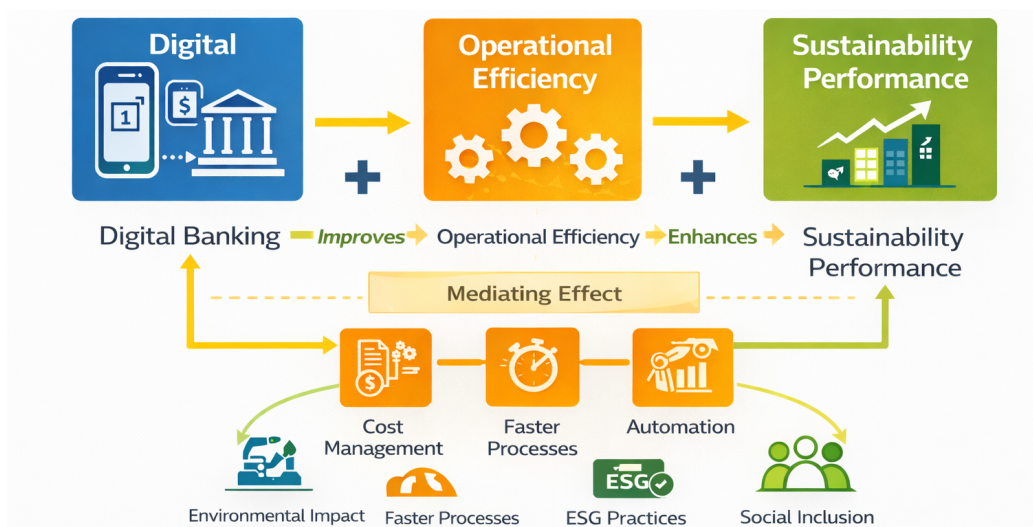


Figure 3. Impact of Digital Banking on Efficiency and Sustainability Performance

Figure 3 illustrates the impact of digital banking adoption on operational efficiency and sustainability performance. The diagram shows that digital banking improves operational efficiency through cost management, faster processes, and automation. Improved operational efficiency subsequently enhances sustainability performance, including environmental impact reduction, ESG practices, and social inclusion. The figure also highlights the mediating role of operational efficiency in linking digital banking and sustainable banking outcomes [24].

3.1. Operational Efficiency Enhancement

The findings indicate that digital banking adoption plays a vital role in enhancing operational efficiency in the banking sector. Digital platforms streamline internal processes, reduce manual intervention, and improve transaction speed, allowing banks to optimize resource utilization and lower operational costs. These efficiency gains reflect the ability of digital banking systems to automate routine activities and improve coordination across banking operations [25]. Moreover, improved operational efficiency enables banks to respond more effectively to competitive pressures and changing customer demands.

By leveraging digital banking technologies, banks can achieve higher productivity and operational flexibility, which strengthens their overall performance and supports sustainable operational practices. The improvement in operational efficiency also leads to better cost management and enhanced service scalability

[26]. Digital banking platforms allow banks to process a higher volume of transactions without significantly increasing operational expenses. This scalability supports sustainable growth by enabling banks to expand services while maintaining resource efficiency.

Table 3. Summary of Empirical Findings

Relationship	Effect	Interpretation
Digital Banking → Operational Efficiency	Positive	Improves cost efficiency and automation
Operational Efficiency → Sustainability Performance	Positive	Enhances ESG outcomes
Digital Banking → Sustainability Performance	Positive	Reduces environmental footprint
Mediating Role of Operational Efficiency	Significant	Strengthens sustainability impact

Table 3 summarizes the empirical findings regarding the relationships among digital banking adoption, operational efficiency, and sustainability performance. The results indicate that digital banking positively influences operational efficiency, which subsequently enhances sustainability performance. In addition, digital banking also exerts a direct positive effect on sustainability outcomes. The mediating role of operational efficiency further strengthens the relationship between digital banking and sustainable banking performance.

3.2. Sustainability Performance Improvement

The results further reveal that operational efficiency contributes significantly to improved bank sustainability performance. Efficient banking operations are associated with reduced energy consumption, lower paper usage, and decreased reliance on physical infrastructure. These outcomes support environmentally responsible practices and reinforce banks' commitment to sustainability objectives [27]. In addition, sustainability performance is strengthened through enhanced transparency and accountability enabled by digital systems. Digital banking facilitates more accurate monitoring and reporting of sustainability-related activities, enabling banks to align operational performance with environmental and social responsibilities. This finding highlights the importance of efficiency as a foundation for achieving sustainable banking outcomes.

Furthermore, digital banking supports social sustainability by improving financial accessibility and customer engagement. Online platforms enable customers to access banking services regardless of geographic limitations, promoting inclusive financial participation. This inclusive approach strengthens the social dimension of sustainability in the banking sector. In addition, improved operational efficiency allows banks to allocate resources more effectively toward sustainability initiatives, including digital documentation, remote services, and environmentally friendly operational practices. These findings demonstrate that operational efficiency achieved through digital transformation contributes not only to environmental improvements but also to broader social and governance outcomes [28].

3.3. Direct Impact of Digital Banking on Sustainability

Beyond efficiency improvements, the findings show that digital banking exerts a direct positive influence on bank sustainability performance. The adoption of digital channels reduces the need for physical branches and paper-based transactions, thereby lowering the environmental footprint of banking activities [29]. Digital banking also supports data-driven sustainability initiatives by enabling better tracking and evaluation of sustainability performance indicators. This direct relationship suggests that digital banking adoption itself represents a strategic approach to sustainable banking. By integrating digital technologies into core operations, banks can simultaneously improve service delivery and advance sustainability goals.

Moreover, digital banking enhances data transparency, allowing banks to monitor environmental and social indicators more effectively. This transparency improves accountability and strengthens sustainability reporting practices, contributing to long-term stakeholder trust. The use of digital platforms also facilitates collaboration with stakeholders and improves communication regarding sustainability initiatives [30]. As a result, digital banking adoption becomes not only a tool for operational efficiency but also a key driver of sustainable banking practices. These findings indicate that digital transformation directly supports long-term organizational resilience and strengthens the sustainability orientation of banking institutions.

3.4. Efficiency as a Mediating Mechanism

The findings indicate that operational efficiency serves as an important mechanism linking digital banking and bank sustainability performance. Digital banking enhances efficiency, which in turn strengthens sustainability outcomes, demonstrating the indirect pathway through which digital transformation supports sustainable banking practices. This mediating role highlights the strategic importance of efficiency in translating technological investments into long-term sustainability benefits. Banks that improve operational efficiency through digital adoption are better positioned to implement sustainability initiatives and optimize resource utilization [31].

Overall, the combined direct and indirect effects confirm that digital banking adoption contributes to sustainable banking performance through multiple channels. These findings emphasize that banks seeking to achieve sustainability objectives should prioritize digital strategies that enhance operational efficiency while supporting responsible and environmentally conscious business practices [32]. Furthermore, operational efficiency not only improves financial performance but also reinforces sustainable operational practices by reducing resource consumption and improving process optimization. Banks that successfully integrate digital technologies into operational processes are more likely to achieve balanced economic, environmental, and social outcomes, thereby strengthening the long-term sustainability of the banking sector [33].

4. MANAGERIAL IMPLICATION

The findings of this study provide important managerial implications for banking executives in designing and implementing effective digital transformation strategies. The positive relationship between digital banking and operational efficiency suggests that investments in digital technologies should be positioned as strategic priorities rather than merely technical enhancements. Bank managers need to ensure that digital banking initiatives are fully integrated into core operational processes to maximize efficiency gains, reduce operational costs, and improve service delivery. This integration allows banks to achieve higher productivity and responsiveness in an increasingly competitive and technology-driven financial environment.

Furthermore, the significant role of operational efficiency in enhancing sustainability performance highlights that efficiency should not be viewed solely as a financial objective, but also as a key driver of sustainable practices. Managers are encouraged to align efficiency improvements with environmental and social goals, such as reducing paper usage, minimizing reliance on physical infrastructure, and optimizing energy consumption through digital platforms. By doing so, banks can simultaneously achieve cost efficiency and contribute to broader sustainability objectives, particularly those aligned with ESG principles and SDGs.

In addition, the direct and indirect effects of digital banking on sustainability performance indicate that digital transformation can serve as a comprehensive strategy for long-term organizational resilience. Bank executives should invest in digital capability development, including employee training, data analytics, and system integration, to fully leverage the benefits of digitalization. Collaboration with technology providers and regulators is also essential to ensure secure, scalable, and sustainable digital banking ecosystems. Ultimately, a well-executed digital strategy will not only enhance operational efficiency but also strengthen banks' ability to achieve sustainable growth and maintain competitive advantage in the evolving financial landscape.

5. CONCLUSION

This study examines the relationship between digital banking, operational efficiency, and sustainability performance in the banking sector. The results demonstrate that digital banking adoption has a significant positive effect on operational efficiency, which in turn enhances sustainability performance. In addition to this indirect effect, digital banking also directly contributes to sustainability outcomes, indicating that digital transformation plays a dual role in improving both internal efficiency and external performance. These findings confirm that digital banking is a critical enabler of modern banking practices that support both economic and sustainable objectives.

Moreover, the study highlights the important mediating role of operational efficiency in linking digital banking and sustainability performance. This suggests that efficiency acts as a key mechanism through which technological investments are translated into meaningful sustainability outcomes. Banks that successfully leverage digital technologies to optimize their operations are better positioned to reduce environmental impact, improve resource utilization, and enhance transparency and governance practices. Therefore, operational efficiency should be considered a strategic bridge that connects digital innovation with long-term sustainability


performance.


Despite its contributions, this study acknowledges certain limitations that open avenues for future research. Future studies may expand the model by incorporating additional variables such as artificial intelligence, big data analytics, or digital risk management to better capture the complexity of digital transformation in banking. Additionally, applying alternative methodologies such as structural equation modeling or conducting cross-country comparisons could provide deeper insights into the generalizability of the findings. Overall, this study emphasizes that integrating digital banking with operational efficiency is essential for achieving sustainable banking performance and long-term resilience in an increasingly digital and sustainability-oriented financial environment.

6. DECLARATIONS

6.1. About Authors

Max ABR. Soleman Lenggu (MA)  -

Muhtarom (M)  <https://orcid.org/0009-0002-1497-9574>

Noah Rangi (NR)  <https://orcid.org/0009-0004-6616-956X>

Meriyana Sunengsih (MS)  <https://orcid.org/0009-0002-6480-1571>

6.2. Author Contributions

Conceptualization: MS; Methodology: M; Software: MA; Validation: MA and NR; Formal Analysis: MS and M; Investigation: NR; Resources: M; Data Curation: MS; Writing Original Draft Preparation: NR and MS; Writing Review and Editing: M and NR; Visualization: RS; All authors, MA, M, NR, and MS, have read and agreed to the published version of the manuscript.

6.3. Data Availability Statement

In line with our commitment to research transparency, the dataset underlying this study has been archived in the Zenodo Repository <https://zenodo.org/records/19367150> and is accessible upon request to the corresponding author.

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6.5. Declaration of Conflicting Interest

The authors state that there are no conflicts of interest, including any known competing financial interests or personal relationships, that could have influenced the results presented in this paper.

REFERENCES

- [1] L. A. Bueno, T. F. Sigahi, I. S. Rampasso, W. Leal Filho, and R. Anholon, "Impacts of digitization on operational efficiency in the banking sector: Thematic analysis and research agenda proposal," *International Journal of Information Management Data Insights*, vol. 4, no. 1, p. 100230, 2024.
- [2] M. Celestin, "The impact of digital banking on corporate financial operations: How businesses are adapting to fintech innovations," *Brainae Journal of Business, Sciences and Technology*, vol. 6, no. 6, pp. 941–952, 2022.
- [3] W. Aslam and S. T. Jawaid, "Green banking adoption practices: improving environmental, financial, and operational performance," *International Journal of Ethics and Systems*, vol. 39, no. 4, pp. 820–840, 2023.
- [4] D. Tribuana, U. Narimawati, and M. Y. Syaifei, "A multi-group structural analysis of digital banking adoption determinants across generational cohorts in indonesia," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 8, no. 1, pp. 37–50, 2026.

- [5] I. Siswanti, H. A. Riyadh, Y. F. Cahaya, E. Prowanta, and B. A. H. Beshr, “Unlocking sustainability: exploring the nexus of green banking, digital transformation, and financial performance with foreign ownership moderation,” *Discover Sustainability*, vol. 5, no. 1, p. 379, 2024.
- [6] Y.-C. Chen, T.-Y. Lin, Y.-h. Chiu, and C.-I. Yang, “An exploration of operational efficiency, market efficiency, and sustainable development in the banking industry,” *Corporate Social Responsibility and Environmental Management*, vol. 31, no. 5, pp. 4819–4848, 2024.
- [7] E. Pradivta, F. P. Oganda, E. T. Persada, U. Rahardja *et al.*, “Scalability and security challenges of cloud computing in the banking industry,” in *2024 6th International Conference on Cybernetics and Intelligent System (ICORIS)*. IEEE, 2024, pp. 1–6.
- [8] I. Anis, L. Gani, H. Fauzi, A. A. Hermawan, and D. Adhariani, “The sustainability awareness of banking institutions in indonesia, its implication on profitability by the mediating role of operational efficiency,” *Asian Journal of Accounting Research*, vol. 8, no. 4, pp. 356–372, 2023.
- [9] N. Toni, T. S. Goh, Y. R. Edward *et al.*, “Supply chain sustainability and financial performance: The role of e-commerce, digital banking and digital marketing of smes.” *Economics: Innovative & Economic Research Journal/Casopis za Ekonomsku Teoriju i Analizu*, vol. 13, no. 1, 2025.
- [10] K. Mazayo, S. Agustina, and R. Asri, “Application of digital technology risk management models in banking institutions reflecting the digital transformation of indonesian banking blueprint,” *International Journal of Cyber and IT Service Management (IJCITSM)*, vol. 3, no. 2, pp. 130–143, 2023.
- [11] I. Hidayat-ur Rehman and M. N. Hossain, “The impacts of fintech adoption, green finance and competitiveness on banks’ sustainable performance: digital transformation as moderator,” *Asia-Pacific Journal of Business Administration*, vol. 17, no. 4, pp. 987–1020, 2025.
- [12] Y. Zhu and S. Jin, “How does the digital transformation of banks improve efficiency and environmental, social, and governance performance?” *Systems*, vol. 11, no. 7, p. 328, 2023.
- [13] A. B. Fitra, A. Suharko, F. M. Albar, D. Apriliasari *et al.*, “Examination of customer interest in the use of the mandiri syariah mobile application at pt. bank syariah mandiri bekasi branch office,” *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, vol. 3, no. 2, pp. 110–125, 2022.
- [14] S. Acheampong, T. Pimonenko, and O. Lyulyov, “Sustainable marketing performance of banks in the digital economy: The role of customer relationship management,” *Virtual Economics*, vol. 6, no. 1, pp. 19–37, 2023.
- [15] Z. Mamadiyarov, S. J. Khamdamov, S. Makhmudov, L. Mirpulatova, E. Shadmanov, U. Berdieva, and N. Shaislamova, “The impact of digital technologies on the operational efficiency of commercial banking institutions,” in *Proceedings of the 8th International Conference on Future Networks & Distributed Systems*, 2024, pp. 623–627.
- [16] R. Habibi and A. C. Panjaitan, “A model for blood bank facility-location problem at post disaster area,” *ADI Journal on Recent Innovation*, vol. 4, no. 2, pp. 128–137, 2023.
- [17] C. Molla, M. R. I. Bhuiyan, M. T. Islam, and A. Amin, “Mediating role to banking performance for adopting digital bank using a technology organizational environment model,” *Digital Finance*, vol. 8, no. 1, p. 4, 2026.
- [18] I. Mavlutova, A. Spilbergs, A. Verdenhofs, A. Natrins, I. Arefjevs, and T. Volkova, “Digital transformation as a driver of the financial sector sustainable development: An impact on financial inclusion and operational efficiency,” *Sustainability*, vol. 15, no. 1, p. 207, 2022.
- [19] I. Siswanti, H. A. Riyadh, L. C. Nawangsari, Y. F. Cahaya, and Y. M. Putra, “Integrating green banking into sustainable development strategies for commercial bank efficiency,” *Aptisi Transactions on Technopreneurship (ATT)*, vol. 8, no. 1, pp. 351–364, 2026.

- [20] X. Zhang, Z. Wang, X. Zhong, S. Yang, and A. B. Siddik, "Do green banking activities improve the banks' environmental performance? the mediating effect of green financing," *Sustainability*, vol. 14, no. 2, p. 989, 2022.
- [21] N. T. H. Nguyen, N. Kim-Duc, and T. L. Freiburghaus, "Effect of digital banking-related customer experience on banks' financial performance during covid-19: a perspective from vietnam," *Journal of Asia Business Studies*, vol. 16, no. 1, pp. 200–222, 2022.
- [22] F. Ariyanto, N. P. L. Santoso, M. F. Kamil, and U. Rahardja, "Innovative mobile banking solutions powered by 5g: Ensuring security and seamless connectivity," in *2024 6th International Conference on Cybernetics and Intelligent System (ICORIS)*. IEEE, 2024, pp. 01–05.
- [23] M. Shehadeh, D. Almajali, I. A. Abu-AlSondos, A. F. Alkhwaldi, and A. S. Al-Gasaymeh, "Digital transformation and its impact on operational efficiency and competitive advantage in islamic banks," in *2023 international conference on business analytics for technology and security (ICBATS)*. IEEE, 2023, pp. 1–6.
- [24] A. A. Mir and A. A. Bhat, "Green banking and sustainability—a review," *Arab Gulf Journal of Scientific Research*, vol. 40, no. 3, pp. 247–263, 2022.
- [25] D. E. E. Saputra, D. Susita, A. Eliyana, A. S. Pratama, M. H. Muzakki, and Z. Yazid, "Employees intentions to use performance management system in regional bank: Perspective from generation-x," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 6, no. 3, pp. 550–561, 2024.
- [26] B. Kuosuwan, A. Risman, E. Dudukalov, and E. Kozlova, "Digital banking and environmental impact: How fintech supports carbon footprint reduction," in *BIO Web of Conferences*, vol. 145. EDP Sciences, 2024, p. 05017.
- [27] I. A. Tsindeliani, M. M. Proshunin, T. D. Sadovskaya, Z. G. Popkova, M. A. Davydova, and O. A. Babayan, "Digital transformation of the banking system in the context of sustainable development," *Journal of Money Laundering Control*, vol. 25, no. 1, pp. 165–180, 2022.
- [28] A. Ekawaty, E. A. Nabila, S. A. Anjani, U. Rahardja, and S. Zebua, "Utilizing sentiment analysis to enhance customer feedback systems in banking," in *2024 12th International Conference on Cyber and IT Service Management (CITSM)*. IEEE, 2024, pp. 1–6.
- [29] H. Gutiérrez-Ponce and S. A. Wibowo, "Do sustainability activities affect the financial performance of banks? the case of indonesian banks," *Sustainability*, vol. 15, no. 8, p. 6892, 2023.
- [30] R. Lohano, M. A. Jariko, and M. Memon, "The influence of digital banking services on financial performance: A focus on customer experience," *Progressive Research Journal of Arts and Humanities*, vol. 6, no. 1, pp. 89–100, 2024.
- [31] R. D. M. Iskandar, T. Maryanti, A. R. Jayaprawira, and S. N. Sari, "Indonesian islamic banking fintech model strategy: Anp method," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 4, no. 2, pp. 142–152, 2022.
- [32] S. I. Zaman, S. A. Khan, S. Qabool, and H. Gupta, "How digitalization in banking improve service supply chain resilience of e-commerce sector? a technological adoption model approach," *Operations Management Research*, vol. 16, no. 2, pp. 904–930, 2023.
- [33] Bank Indonesia, "Monetary policy report - quarter ii 2023," Bank Indonesia, Monetary Policy Report, Jul. 2023. [Online]. Available: <https://www.bi.go.id/en/publikasi/laporan/Pages/Laporan-Kebijakan-Moneter-Triwulan-II-2023.aspx>